TRACHEA AND THE MODE OF BRANCHING OF BRONCHIAL TREE

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CERTIFICATE

This is to certify that the dissertation entitled “Trachea and the mode of branching of bronchial tree” is the bonafide record of work done by **Dr.B.SANTHI** in the Department of Anatomy, Thanjavur Medical College, Thanjavur during her Post Graduate course from 2005-2008. This is submitted as partial fulfillment for the requirement of M.S Degree Examinations-Branch V (Anatomy) to be held in March 2008.

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INTRODUCTION

The trachea provides a passageway for inhaled gas to reach the gas-exchange regions of the lungs from the atmosphere. Its characteristic anatomy provides the surgeon with many challenges. Knowledge of anatomy is essential to the study of airway management. The rigidity of trachea is provided by cartilaginous rings that extend approximately two-thirds the circumference. Both benign and malignant processes affect trachea necessitating treatment. The initial evaluation of patients with suspected tracheal pathology includes a thorough history and physical examination, standard chest x-ray and neck x-ray, CT scan can determine local extension, degree of luminal compromise and the length of the trachea that is involved. Bronchoscopy is required in the evaluation and treatment of tracheal pathology.

Tracheostomy should be considered in the presence of severe maxillofacial injury to ensure an adequate airway. The golden rule of tracheostomy based entirely on anatomical considerations- “is stick exactly in the midline”.

In the present work, the effort will be to provide an account of the structure of the lungs, with particular attention to its application in thoracic surgery. More and more, rational dissection has come to replace the unnecessarily destructive method of mass ligature at the hilum. The availability of effective chemotherapy,

especially for tuberculosis, has made the benefits of segmental resection available to an ever increasing number of patients. Peripheral lesions can be removed by “wedge” resection, but there has renamed a definite need for more direct attack on lesions confined to a single segment deep within a lobe, where conservation of tissue is of paramount importance. Here an account of knowledge of bronchial and vascular relationships is essential, if these operations are to be done with maximum safety.

AIM OF STUDY

1. To study the anatomical variations in length, diameter and number of tracheal rings.

2. To study the anatomical variations in length, angle and the divisions of primary bronchus.

3. To study the anatomical variations of bronchial tree in right and left lungs.

HISTORICAL PERSPECTIVE

Knowledge like a coral reef is built upon foundations created in the past. The story begins with the scientific revolution and the words of the first medical microscopist : “Magnum certum opus oculis video” (I see with my own eyes a certain great thing).

In 1880 Christoph Theodor Aeby – published a treatise having the postulates that the human bronchial tree was made up of two axial stems with monopodial types of branching, eparterial, hyparterial bronchi.

Two years after Aeby’s death, Wilhelm His, great embryologist substantiated Aeby’s theory of the mode of branching of the bronchial tree. Twelve years later Hasse employed Aeby’s terminology with some modification.

Ewart’s monograph of 1889 was a monumental work of great originality and precision. He described the reason for the disappearance of the axial type in man was held to be a consequence of the difference in the thorax of man and the quadrupeds.

In Ewarts work he described nine bronchial distributions. Apical, axillary, pectoral, cardiac, posterior-horizontal, retro-cardiac, anterior-basic, axillary-basic and posterior-basic.

Three decades later, the American anatomist George S. Huntington described that the pulmonary anlage of mammals is to be considered as plastic, permitting a “selection” of sites where bronchial buds may proliferate according to the demands of the environment. Consequently, a hyparterial type is not derived by “reduction” from an eparterial type (Aeby) or an eparterial type by “extension and migration of bronchi” (Narath).

In 1919 – Robert Heiss demonstrated in human embryos the primitive lung sacs give rise not to two axial stems but to five zones of growth – three on the right and two on the left – each of which develops into a lobar bronchus and its own pattern of arborization.

In 1920, Felix republished Hasse’s figures in the second edition of sauerbruch’s chirurgie der Brustorgane. Thus Aeby’s interpretation of the human bronchial tree became the clinical map of the lung.

In 1932 Glass named both the segment and its bronchus as broncho pulmonary segment which is “not only an anatomic but a pathologic unit.”

In 1933, Rienhoff reported the use of hilar dissection in each of the two successful pneumonectomies.

In 1936 Lucien and Weber recognized 14 territories of ventilation in each lung.

In 1939 Churchill and Belsey established the principle that the broncho pulmonary segments are surgical units.

In 1939 Pierce and Stocking greatly improving the interpretation of structures seen in bronchograms.

Churchill and Belsey in 1939 and Blades and Kent in 1940 and 1942, further demonstrated the feasibility of precise anatomical dissection of the bronchus and related structures not only at the lobar level but in some instances at the segmental level.

In January 1942, by the work of A.F.Foster-Carter, the first thorough going clinico-anatomical account of the tree appeared.

In 1943 – the names selected and devised by Jackson and Huber applied to particular segments of bronchi of the human lung at least in origin, the terminology is international.

In 1946, R.C. Brock represented the accurate localization of lesions in the segments of the lung.

1951, Ando stated that even in identical twins, the pattern of corresponding lobes may vary.

In September 1952, an excellent survey of prevailing patterns and variations in the segmental bronchi, arteries and veins of the right lung appeared under the authorship of G.C. Cordier and C. Cabrol.

Claus Esser, a German radiologist first identified the normally placed sub segmental bronchi in bronchograms.

In 1955, the crowning achievement in the elucidation of the anatomy of the lung was represented by Dr. Edward A.Boyden and his co-workers.

NORMAL ANATOMY

Trachea

The trachea is the continuation of larynx and commences in the neck below the cricoid cartilage at the level of C6 vertebra, 5cm above the jugular notch. Entering the thoracic inlet in the midline it passes downwards and backwards behind the manubrium to bifurcate into the two principal or main bronchi on a level just below the lower border of manubrium. This is true of the recumbent cadaver, in whom the trachea is about 10cm long and 2cm in diameter, in the living the bifurcation may be 5cm lower in full inspiration. The patency of the trachea as an airway, its essential function is maintained by 15-20 horse shoe-shaped hyaline cartilages (commonly called tracheal rings although they are never complete circles). The gap in the rings are at the back, where there is smooth muscle, mostly transversely placed (the trachealis muscle)

Blood supply

Branches from the inferior thyroid and bronchial arteries form anastamotic networks in the tracheal wall. Veins drain to the inferior thyroid plexus.

Lobar and segmental bronchi

Because the left lung grows into a smaller cavity than the right, the way bronchi divide to supply segments of lung is not identical on the two sides, although there are close similarities.

From the bifurcation of the trachea each main bronchus passes downwards and laterally to enter the hilum of the lung. They are approximately 5 cm (2 in) in length, but the right is slightly shorter and more vertical than the left.

Each main bronchus gives rise to lobar bronchi that supply the lobes of the lung. The right main bronchus gives off the upper lobe bronchus outside the hilum and ends within the hilum by dividing into middle and lower lobe bronchi. The left main bronchus divides within the hilum into upper and lower lobar bronchi.

Each lobar bronchus gives rise to further branches, the segmental bronchi for each segment of the lung. There are typically 10 broncho pulmonary segments in each lung and therefore 10 segmental bronchi are to be expected. Ten individual segmental bronchi can usually be distinguished on the right, but on the left it is usual for one or more segmental bronchi to share a common stem.

The broncho pulmonary segments are listed as follows :

RIGHT LUNG	LEFT LUNG
Upper lobe	**Upper lobe**
1. Apical	1. Apicoposterior
2. Posterior	2.
3. Anterior	3. Anterior
Middle lobe	**Middle lobe**
4. Lateral	4. Superior lingular
5. Medial	5. Inferior lingular
Lower lobe	**Lower lobe**
6. Apical (superior)	6. Apical (superior)
7. Medial basal (cardiac)	7. Medial basal (cardiac)
8. Anterior basal	8. Anterior basal
9. Lateral basal	9. Lateral basal
10. Posterior basal	10. Posterior basal

In the right, the upper lobe bronchus arises high up on the side of the main bronchus outside the hilum and on both sides the apical segment of the lower lobe is supplied by a bronchus (6), which is the highest to arise from the posterior surface of the bronchial tree.

Blood supply

The bronchial tree receives its own arterial supply by the bronchial arteries. There are usually three: two on the left which are direct branches from the aorta, and one on the right coming from the third right posterior intercostal artery. The bronchial veins fall into a superficial system draining from the hilar region.

Radiological anatomy

The bronchial tree can be visualized in x-ray after injecting radio-opaque compounds into the trachea and its branches (bronchogram).

The lung fields are seen as dark translucent shadows in plain x-ray chest because of the air they contain. Hence the lung shadow more especially at the base is appreciably more translucent on inspiration. The blood vessels because of the contrast provided by the contained blood stand out as radiating shadows (hilar shadows) from the hilus of the lung. Since x-rays are taken in the upright position the shadow of vessels in the upper half are rather smaller than those in the lower half. Towards the periphery the vessels are too small to be seen. The hilar lymph nodes may also be visible as opaque shadows.

REVIEW OF LITERATURE

TRACHEA

William E. Bloomer (1889) described that the trachea is ll cm long.

Hein rich von Hayek (1960) described that the length of the trachea is 10 to 12 cm. Width 13 to 22 mm. The transverse diameter being about ¼ greater than the sagittal diameter.

W. Henry Hollinshead (1966) described that the length of the trachea is 18mm. The tracheal bronchus is rarely encountered. Bremer found the tracheal bronchi in 5% of young embryos.

Cunningham (1972) described that the length of trachea is 9-15 cm in adult. Sagittal and coronal diameter is 16x14 mm in adults. External diameter of trachea is 2cm in adult male and rather less in adult female. The number of tracheal rings is about 15-20.

J.G. Scadding, Gordon cumming (1981) in scientific foundations of respiratory medicine described that the trachea is 10cm long and 13 to 22mm in width.

Robert G. Fraser, J.A. Peter pare, P.D. Pare, Richard S.Fraser, George P.Genereux (1988) described that the diameter of trachea measured in asymmetric model of airways derived from measurement of a cast is 16mm. Trachea has horse shoe shaped cartilage rings at regular intervals.

Richard S. Snell (1993) stated that the trachea is a mobile tube about 5 inches (13cm) long and 1 inch (2.5cm) in diameter. It has a fibro elastic wall in which are embedded a series of U shaped bars of hyaline cartilage that keep the lumen patent.

Anthony Seaton, Douglas Seaton, Gordon Leitch (1995) described that the length of the trachea is 10-12 cm. It is oval in cross section containing semi circular tracheal cartilages.

Last (1996) stated that the trachea is about 10cm long and 2cm in diameter.

Georg G. Burton, John E.Hodgkin, Josbery J.Ward (1997) in respiratory medicine described that the trachea is a D shaped tubular structure with a flattened posterior surface. In the adult its length extends approximately 12 to 15cm from cricoid to bronchial bifurcation. It is 1.8 to 2.5 cm in diameter. The anterior and lateral surfaces are supported by 16 to 22 C shaped cartilage rings.

J.N. Pande (1998) described that the length of the trachea depends upon the posture, position of neck in relation to the thorax and the phase of respiration. In young and healthy subjects the tracheal lumen is almost round in shape. In elderly and in patients with chronic bronchitis the transverse diameter is greater than the antero posterior diameter particularly during expiration.

Cecil (2000) described that the adult human trachea is approximately 2.5cm in length and 2.5cm in diameter having 15 to 20 horse shoe shaped cartilaginous rings.

Frederic H Martini & Michael J. Timmons (2000) in human anatomy described that the tracheal diameter is 2.5.cm (1 inch) and length is approximately 11cm (4.25 inches). The tracheal cartilages are C shaped and the number varies from 15-20 rings.

Ronald B. George, Richard W. Light, Michael A. Matthay, Richard A. Matthay (2000) described that the length of the trachea is 10-12 cm.

Peter L. Williams (2000) in Gray's anatomy described that the trachea is 10-11cm long, external transverse diameter is about 2 cm in adult males and 1.5cm in adult females. In living, lumen is smaller than the dead, its

diameter in adults being 12mm. The transverse shape of the human is variable especially in later decades being round, lunate or flattened. In Chinese tracheal lumen averaged 16-17 mm (range 9.5 – 22 mm).

Harold Ellis (2002) described that the trachea is about 4.5 inches (11.5cm) in length and nearly 1 inch (2.5cm) in diameter. The patency of trachea is maintained by a series of 15-20 U shaped cartilages.

Warren M.Gold (2002) described that the diameter of trachea is 18mm, containing 'U' shaped cartilaginous rings.

C. John Gibson, Duncan M. Geddes, Ulrich Costable, Peter J. Sterk, Bryan Corrin (2003) in respiratory medicine described that the trachea is about 10-11cm long in an average adult. It has 15-20 horse shoe shaped cartilaginous rings which are incomplete posteriorly. The cartilaginous rings show some variations in shape and some are branched.

BRONCHI

Aeby (1880) measured the length of right bronchus as 2.3cm (with a range of 1.5 to 3.4) on the left it was 5.5 cm (with a range of 4.3 to 5.8).

Boyden and Hartmann (1946) described a case in which only the apical branch of upper lobe bronchus laid eparterially; the other branch on the other hand arose hyparterially from left bronchus. Boyden relates this abnormal division of left upper lobe bronchus to an abnormal position of pulmonary artery in development.

Heinrich von Hayek (1960) described that the diameter of right bronchus is 12 to 16mm and left bronchus is 10-14 mm. The ratio of diameters of 2 lobar bronchi is 4:6 less frequently the relation is 3:6 or 2:6. In case of longer branches the angle between two branches is mostly more acute and in smaller one it is a right angle or an obtuse angle. The length of left bronchus is 5cm and right bronchus is 1 to 2½ cm.

The left bronchus courses beneath the left pulmonary artery and for this reason is therefore designated as hyparterial, while the right pulmonary artery crosses caudal to right upper lobe bronchus and so this is called as eparterial bronchus.

W. Henry Hollinshead (1966) described that the length of left bronchus is 4 to 5 cm and leaves the trachea at an angle 45^0 to midline. The right bronchus is 2.5 cm long, forms an angle of about 25^0 with midline.

Cunningham (1972) described that the left principal bronchus is about 5 cm long. The right main bronchus is 5 cm long. The right bronchus angle is 155^0 with trachea. The left bronchus angle is 135^0.

J.G. Scadding, Gordon Cumming (1981) described that the angle of right main bronchus is 35^0 and left main bronchus is 73^0.

Robert G. Fraser, J.A. Peter Pare, P.D. Pare, Richard S. Fraser, George P. Genereux (1988) stated that the length of the right principal bronchus is 2.5cm.

Brenden T. Finucane, Albert H. Santorer described that the length of the right main bronchus is 2cm, and the left main bronchus is 5 cm.

Richard S. Snell (1993) described that the right main bronchus is about 1 inch (2.5cm) long. The left main bronchus is about 2 inches (5cm) long.

Anthony Seaton, Douglas Seaton, Gordon Leitch (1995) described that the left main bronchus is 5 cm long and the right main bronchus is 1-2.5 cm long.

According to Last's Anatomy (1996) each main bronchus is approximately 5cm (2 inches) long, but the right is slightly shorter and more vertical than the left.

George G. Burton, John E. Hodgkin, Jeffrey J. Ward (1997) described that in the adult the right side's branching angle is more vertical than left side from midline.

J.N. Pande (1998) described that the left main bronchus is more sharply angulated from the trachea than the right. The length of the left main bronchus is 4 to 5 cm in an adult.

According to Gray's Anatomy (2000) 37th edition the right principal bronchus is 2.5 cm long. The left principal bronchus is 5 cm long.

Ronald B. George, Richard W. Light, Michael A. Matthay, Richard A.Matthay (2000) described that the angle between right and left main bronchi is normally acute and the length of the left main bronchus is 5 cm.

Frederic H. Martini, Michael J. Timmons, Michael P. Mc Kinley, William C. Ober Clais W. Garrison, Kathleon Welch, Rulph T. Hutchings (2000) described that the right main bronchus has a larger diameter than the left and it descends towards the lung at a steeper angle.

Harold Ellis (2002) described that the right main bronchus is about 1 inch (2.5cm) long. The left main bronchus is nearly 2 inches (5cm) long.

C. John Gibson, Duncan M. Geddes, Ulrich Costabel, Peter J. Sterk, Bryan Corrin (2003) described that the right main bronchus is about 2.5cm in an average man. In adults the right main bronchus may have its axis displaced only 20-30^0 from that of trachea, whereas the left main bronchus makes an angle of about 70^0.

BRONCHO PULMONARY SEGMENTS

According to Brock (1943) in 61% of 100 dissected specimens, subsuperior and accessory subsuperior present in 48% of 50 specimens. The distribution of accessory subsuperior in the absence of subsuperior is 38%. The prevailing pattern is both subsuperior and accessory subsuperior present in the same specimen in 45%.

The subsuperior proper on left side occurs in 27% and on right side in 61%. The number of specimens in which there are one, two or more subsuperior is much greater on the left (80%) than on the right (57%).

Berg and his colleagues (1949) found an accessory subsuperior arising as a single branch of posterior basal in 71% and as two branches in 13% and an accessory subsuperior from lateral basal in 67%.

Berg, Boyden, Smith (1949) said that in basal trunks bifurcation occurred in 87% and trifurcation occurred in 13%. In 67% the bronchus gives accessory subsuperior in contrast to right where an accessory sub superior rarely occurs.

Subsuperior bronchi is found in 60% according to Boyden and Ferry (1951) in 50 dissected specimens.

Superior Segmental Bronchus

Arises as a Single Trunk	Pitel+ Boyden (50)	Berg+ Boyden (60)	Total (110)
Arises as a Single Trunk			83.70%
Bifurcates into	42%	43%	42.70%
Trifurcates into	14%	15%	14.50%
Arises as 2 separate trunks	2%	0%	0.90%

Basal Trunk

	Pitel & Boyden (50 Spec)	Berg & Boyden (60 Spec)	Total (110)
Bifurcates	56%	66.70%	61.80%
Trifurcates	30%	13.30%	20.90%

Edward A. Boyden (1955) described that the right upper lobe trifurcates in 46% and bifurcates in 54%. The length of right middle lobe bronchus is 18mm (range 12 to 26mm).

It bifurcates in 62% and trifurcates in 2%. The left upper lobe bifurcates in 73% and trifurcates in 27%. In right lower lobe superior segmental bronchus bifurcates in 90% and trifurcates in 6%.

William E. Bloomer (1960) described that in right upper lobe trifurcation occurred in 52% and double bifurcation in 48%. In right middle lobe the length of middle lobe bronchus is from 8 to 25mm average is 13mm. Bifurcation in 96%. Trifurcation is 4%. The bronchial orifices of middle lobar and superior segmental bronchi of lower lobe may be at the same level or overlapping in 18% or at adjacent levels in 10% or at separate levels in 72%. In no instance apical bronchus takes origin at a level higher than that of middle lobe bronchus. In superior segmental bronchus the prevailing pattern of branches is bifurcation in 74%. Trifurcation in 16%. A subsuperior or an accessory subsuperior or both present in 98%. The left upper lobe bifurcates in 86% and trifurcates in 14%. The left lower lobe bifurcates in 67.5% and trifurcates in 4.6%. The subsuperior or accessory subsuperior occur in all left lungs.

Heinrich Von Hayek (1960) described that the trifurcation is found in right and left upper lobe bronchus. In right upper lobe bronchus most other two bifurcations following in close succession. The right lower lobe bronchus most often exhibits 5 larger branches.

W. Henry Hollinshead (1966) described that in right lung the origin of superior segmental bronchus to lower lobe and middle lobe bronchus are at the same level or only a few mm apart. Right upper lobe bronchus arises as

trifurcation in 46% of cases and bifurcation in 54% of cases. The length of the middle lobe bronchus is 18mm usually bifurcates, but in 2 to 3% trifurcation occurs. The superior segmental bronchus of right lower lobe arises very lightly below the level of origins of middle lobe bronchus.

In left upper lobe bifurcation occurs in 74% according to Boyden and Hartmann and trifurcation in 26%. In lower division 73% of cases bifurcates into superior and inferior lingular branches.

Robert G. Fraser, J.A. Peter Pare, P.D. Pare, Richard S. Fraser, George P. Genereux (1988) described that the right upper lobe bronchus most commonly divides into three branches anterior, posterior, apical. The infrequent origin of upper lobe bronchus or one of its branches (usually the apical bronchus) from the lateral wall of the trachea (the tracheal bronchus). The intermediate bronchus continues for 3 to 4 cm and then bifurcates to become the bronchi to middle and lower lobes. The superior segmental bronchus arises almost opposite to the middle lobe bronchus. The bronchus of left upper lobe either bifurcates or trifurcates usually the bifurcation.

Richard S. Snell (1993) described that before entering the hilum of right lung the principal bronchus gives off superior lobar bronchus. On entering the hilum it divides into a middle and inferior lobar bronchus. On

entering the hilum of left lung the main bronchus divides into a superior and an inferior lobar bronchus.

R.M.H. MC Minn (1996) in Last's anatomy described that the right main bronchus gives off the upper lobe bronchus outside the hilum and ends within the hilum into upper and lower lobar bronchi. The left main bronchus divides within the hilum into upper and lower lobe bronchus. The upper lobe of right lung has three segments and the middle lobe two and the lower lobe five. The upper lobe of left lung has five segments, the two lowest (lingular) corresponding to the two of the middle lobe of right lung and the lower lobes have five segments.

J.N. Pande (1998) described that the right main bronchus gives out a branch to the right upper lobe of lung at a very short distance from its origin and almost at right angles to it. The right upper lobe bronchus divides into apical, anterior and posterior segmental branches. The middle lobe branch divides into medial and lateral segmental branches of right middle lobe. At the level of origin of middle lobe bronchus is the apical segment of right lower lobe. The left upper lobe branch divides into apicoposterior and anterior segmental branches while the lingular branch divides into superior and inferior lingular branches. An accessory subapical bronchus of right lower lobe may be present in some subjects. The left sometimes arise directly

from the upper division of left main bronchus. Rarely the right upper lobe bronchus may arise directly from the trachea.

Peter L. Williams (2000) in Gray's anatomy described that the right superior lobar bronchus about 1cm from its origin divides into three segmental bronchus. In more than half of all right lungs a subsuperior (sub apical) segmental bronchus arises posteriorly from the inferior lobar bronchus 1-3 cm below the superior segmental bronchus. A subsuperior (subapical) segmental bronchus arises posteriorly from the left inferior lobar bronchus in 30% of lungs.

Ronald B. George, Richard W. Light, Michael A. Matthay, Richard A. Matthay (2000) described that the subapical bronchi are present in the lower lobes.

Harold Ellis (2002) in clinical anatomy described that the left upper lobe bronchus gives off a combined apicoposterior and an anterior branch whereas all three branches are separate on right side. On the right there is a small medial (or cardiac) lower lobe bronchus which is absent on the left the lower being otherwise mirror images of each other.

Cunningham (2003) described that the medial basal bronchus is not normally recognized in the left lung. Left superior lobar bronchus is larger than the right.

C. John Gibson, Duncan M. Geddes, Ulrich Costabel, Peter J. Sterk, Bryan Corrin (2003) in respiratory medicine described that the right upper lobe bronchus comes off the right main bronchus only a few cm from its origin. The position of right upper lobe shows some variation in which the lobe opens off the trachea itself (Tracheal bronchus).

MATERIALS AND METHODS

The 50 pairs of specimens for this present study were obtained from the embalmed cadavers of Anatomy Department and also from the postmortemed bodies in the Department of Forensic Medicine, Thanjavur Medical College during the period of study. The specimens were collected without any age, sex, socio-economic status, religion or pathological bias.

The specimen was removed from the cadaver as per the Cunningham's manual of practical anatomy.

An incision is made in the skin from chin to sternum in the midline and the flap of skin is reflected inferolaterally. A transverse incision is made through the deep fascia immediately above the sternum and the deep fascia is reflected.

The infrahyoid muscles are separated to expose the pretracheal fascia. Below the isthmus of the thyroid gland trachea is exposed after removing the pretracheal fascia. A transverse cut is made below the cricoid cartilage and the trachea is separated from the adjacent structures.

A midline incision from supra sternal notch to xiphisternum is made and the skin is reflected. Transverse cut is made through the mannubrium of the

sternum immediately inferior to its junction with the first costal cartilage. A cut is made through the parietal pleura in the first intercostal space on both sides. Then a cut is made inferiorly through the second and subsequent ribs and intercostal spaces from the posterior end of the pleural incision to the level of the xiphisternal joint.

The inferior part of the sternum is elevated with costal cartilages and anterior parts of the ribs. As the anterior part of the sternum is lifted away the parietal pleura is separated along the line of its reflection from the sternum on to the mediastinum to the level of the lower border of the heart. The pleura and endothroacic fasica are striped off from the back of the sternum and costal cartilages. The anterior attachments of the diaphragm to the xiphoid process and costal cartilages are divided. The attachments between the heart and lung are separated. Then the trachea, bronchi and both the lungs are removed from the thoracic cavity.

The specimens collected from the department of forensic medicine were removed during the postmortem. The same procedure was used to remove the specimens.

The specimens thus removed were preserved in 10% formalin and they were serially numbered from 1-100. Odd numbers for right bronchus and even numbers for left bronchus. The specimen was studied with regard to any anatomical variations in trachea, bronchi and broncho pulmonary segments.

OBSERVATION

The trachea and the branching pattern of bronchi studied in 50 pairs of specimens presented the following features.

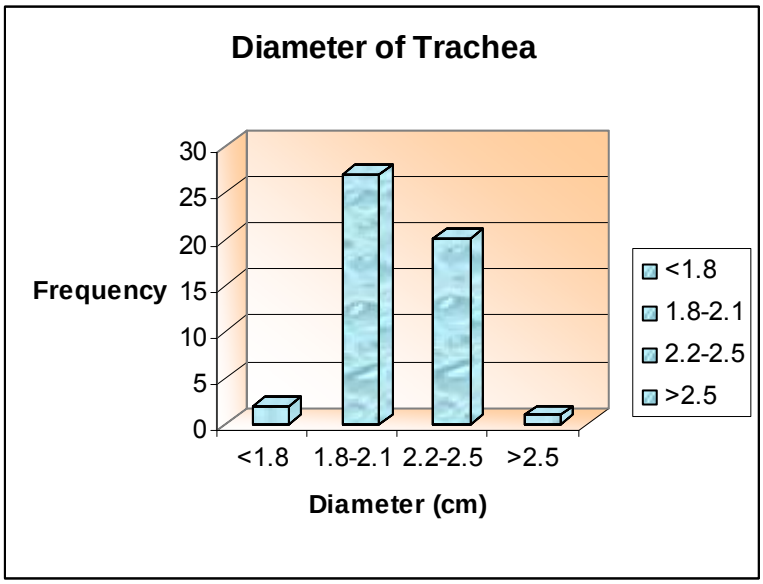
I. DIMENSIONS OF TRACHEA

(a) The diameter of Trachea

The diameter of trachea was found to vary from 1.3cms to 2.6cms, with the average of 2.1cms.

Table No.1

DIAMETER (Cm)	FREQUENCY	SPECIMEN NO.
<1.8	2	(7,8), (25,26)
1.8-2.1	27	(1,2), (3,4), (9,10),…
2.2-2.5	20	(5,6), (21,22), (23,24),…
>2.5	1	(95,96)



In 47 specimens the diameter was found to be in the normal range of 1.8-2.5cms.

In 25 specimens the diameter was found to be less than 1.8cms. Specimen no (7, 8), (25, 26).

In 27 specimens the diameter was found to be in the range of 1.85 to 2cms. Specimen no. (1, 2), (3, 4), (9, 10),..

In 20 specimens the diameter was found to be in the range of 2.2 to 2.5cms. Specimen no. (5, 6), (21, 22), (23,24), ..

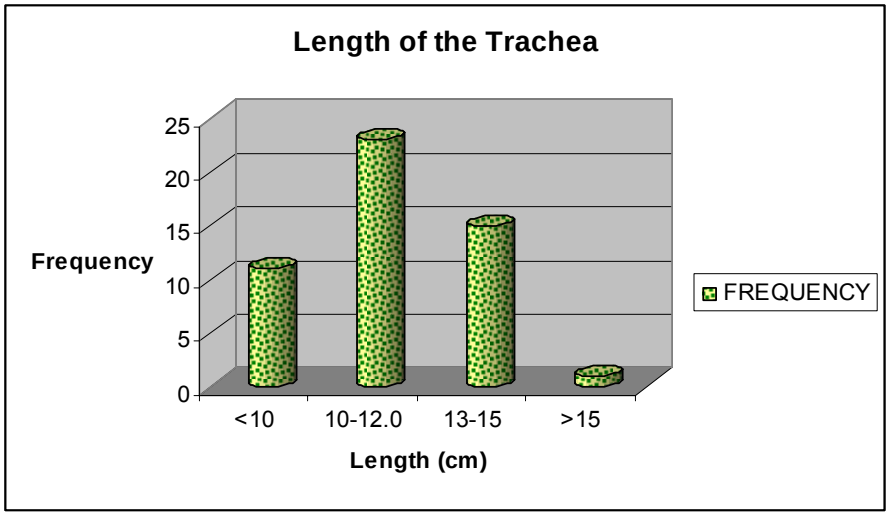
In one specimen the diameter was found to be greater than 2.5cms. Specimen no. (95, 96).

(b) Length of the Trachea

The length of the trachea was found to vary from 6.5cms to 16cms with the average of 11.2cms.

Table No.2

LENGTH	FREQUENCY	SPECIMEN NO.
<10	11	(1,2), (3,4), (7,8),..
10-12.0	23	(5,6),(9,10), (11,12),..
13-15	15	(23,24), (63,64), (65,66),..
>15	1	(91,92)



In 38 specimens the length of the trachea was found to be in the normal range of 10-15cms.

In 11 specimens the length was found to be less than 10cms. Specimen no, (1,2), (3,4), (7,8),..

In 23 specimens the length was found to be in the range of 10-12cms. Specimen no, (5,6),(9,10), (11,12),..

In 15 specimens the length was found to be in the range of 13-15cms. Specimen no. (23, 24), (63, 64), (65,66),..

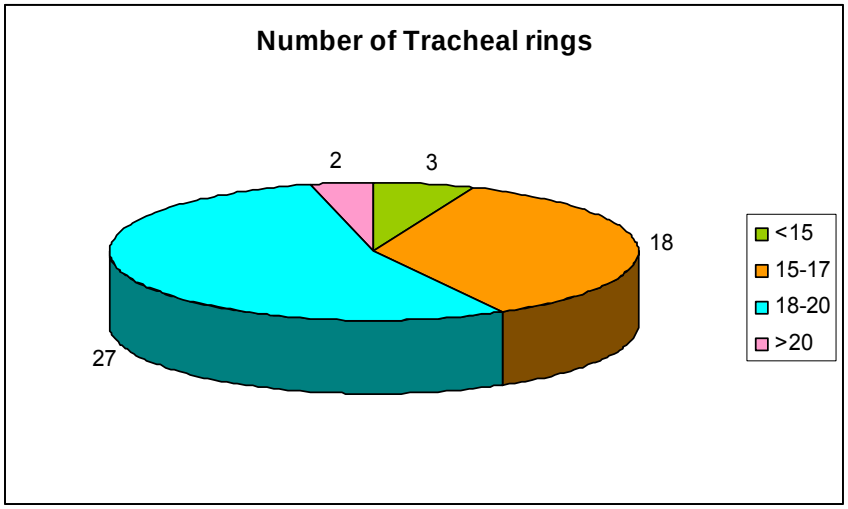
In one specimen length was found to be greater than 15cms. Specimen no, (91, 92).

(c) Number of Tracheal rings.

The number of tracheal rings was found to be in the range of 14 to 22 with the mean of 18.

Table No.3

NO. OF TRACHEAL RINGS	FREQUENCY	SPECIMEN NO.
<15	3	(5,6), (43,44), (57,58),..
15-17	18	3,4), (7,8), (11,12),..
18-20	27	(1,2), (9,10), (15,16),..
>20	2	(51,52), (85,86)



In 45 Specimens the number of tracheal rings was found to be in the normal range of 15-20.

In 3 Specimens the number of tracheal rings was found to be <15. Specimen no. (5,6), (43,44), (57,58),..

In 18 Specimens the number of tracheal rings was found to be in the range 15-17. Specimen no. (3,4), (7,8), (11,12),..

In 27 Specimens the number of tracheal rings was found to be in the range of 18-20. Specimen no. (1,2), (9,10), (15,16),..

In 2 Specimens the number of tracheal rings was found to be >20. Specimen no. (51,52), (85,86).

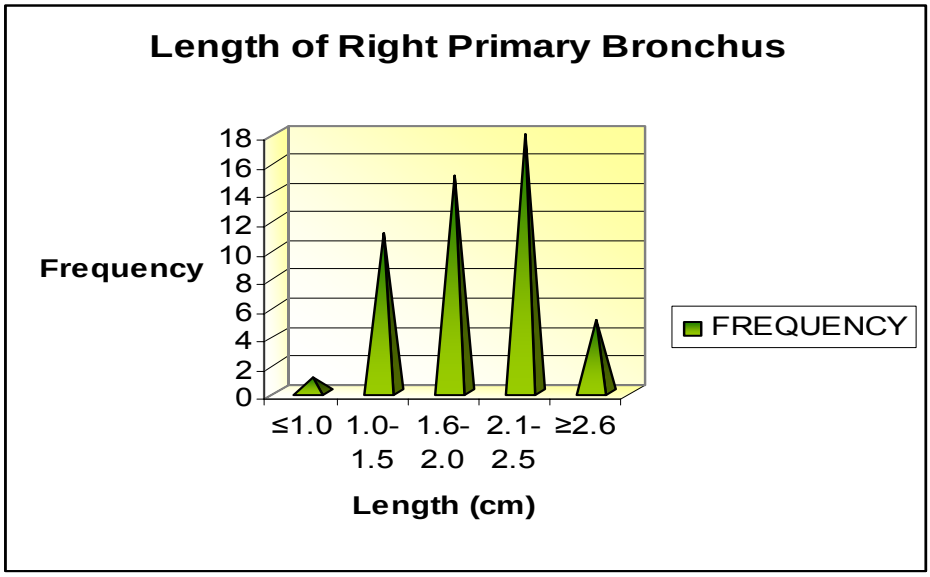
II. RIGHT PRIMARY BRONCHUS

(a) Length of Right Primary Bronchus

The length of the right primary bronchus was found to vary from 1.0cm to 3.0cm with the average of 2.0cm.

Table No.4

LENGTH	FREQUENCY	SPECIMEN NO.
≤1.0	1	75
1.0-1.5	11	9,13,21,..
1.6-2.0	15	7,11,19,..
2.1-2.5	18	1,5,15,17,..
≥2.6	5	3,39,45,..



The length of right primary bronchus was found to be within normal range 1-2.5cm.

In one Specimen the length was found to be 1cm. Specimen no.75.

In 11 Specimens the length varied from 1.1 to 1.5cm. Specimen no. 9, 13, 21,…

In 15 Specimens the length varied from 1.6 to 2.0cm. Specimen no. 7, 11, 19, ..

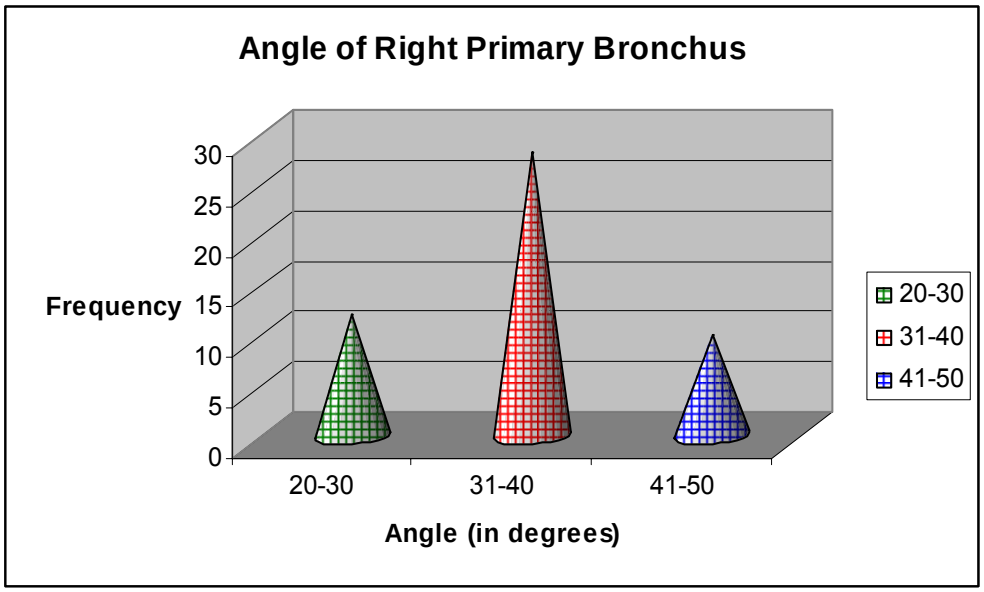
In 5 Specimens the length was ≥2.6cm. Specimen no. 3, 39, 45,..

(b) Angle of right primary bronchus

The angle of right primary bronchus was found to be acute in all specimens, varied from 20° to 50° with the average of 37°.

Table No.5

ANGLE	FREQUENCY	SPECIMEN NO.
20-30	12	1, 13, 27,..
31-40	28	3, 7, 11,..
41-50	10	5, 9, 15,..

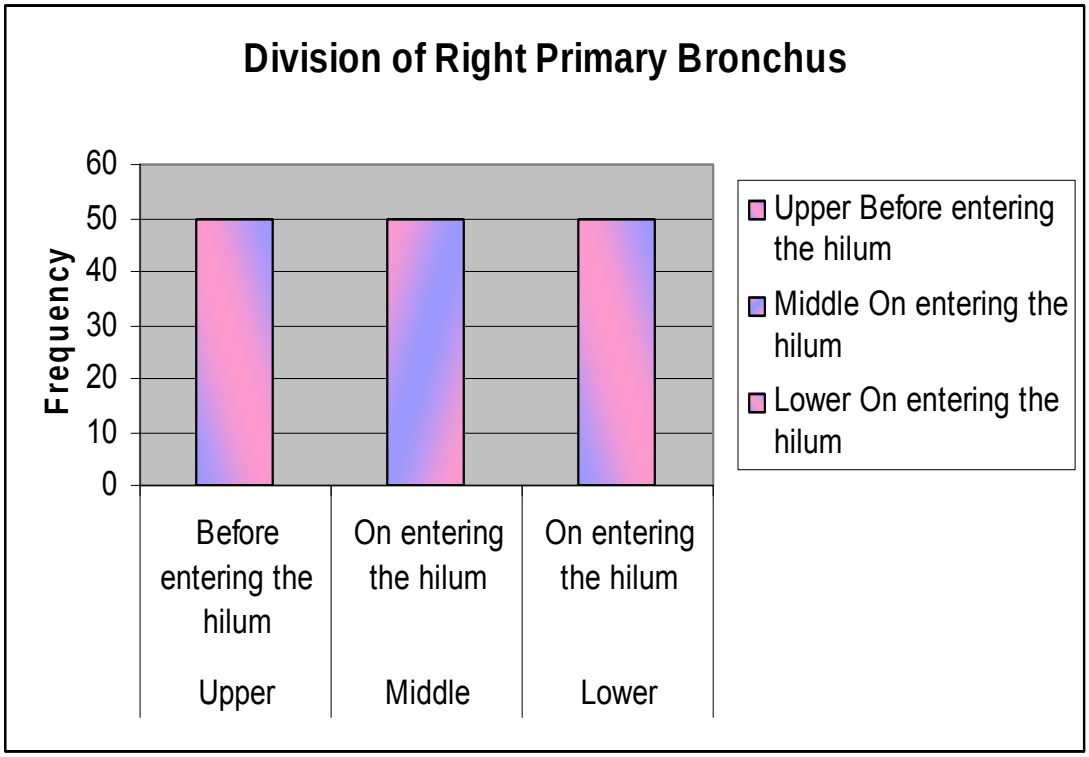


(c) Division of Right Primary Bronchus

The right primary bronchus gives off upper lobar bronchus before entering the hilum it divides into a middle and lower lobar bronchus.

Table No.6

DIVISION OF LOBAR BRONCHUS	SITE OF DIVISION	FREQUENCY
Upper	Before entering the hilum	50
Middle	On entering the hilum	50
Lower	On entering the hilum	50



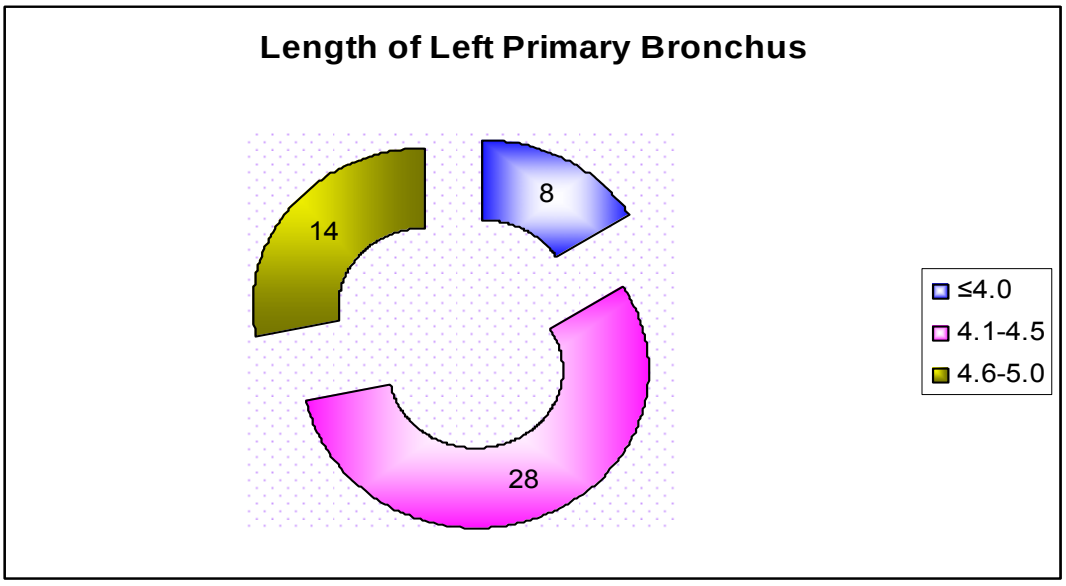
III. LEFT PRIMARY BRONCHUS

(a) The Length of Left Primary Bronchus

The length of left primary bronchus was found to vary from 3.5cm to 5.0cm with the average of 4.4cm.

Table No.7

LENGTH	FREQUENCY	SPECIMEN NO.
≤4.0	8	4, 28, 30,..
4.1-4.5	28	2, 6, 8,..
4.6-5.0	14	10, 18, 20,..



The length of left primary bronchus was found to be within the normal range of 4 to 5cm in 42 specimens.

In 8 specimens the length was ≤4.0cm. Specimen No. 4, 28, 30,..

In 28 specimens the length varied from 4.1-4.5cm. Specimen no. 2, 6, 8,..

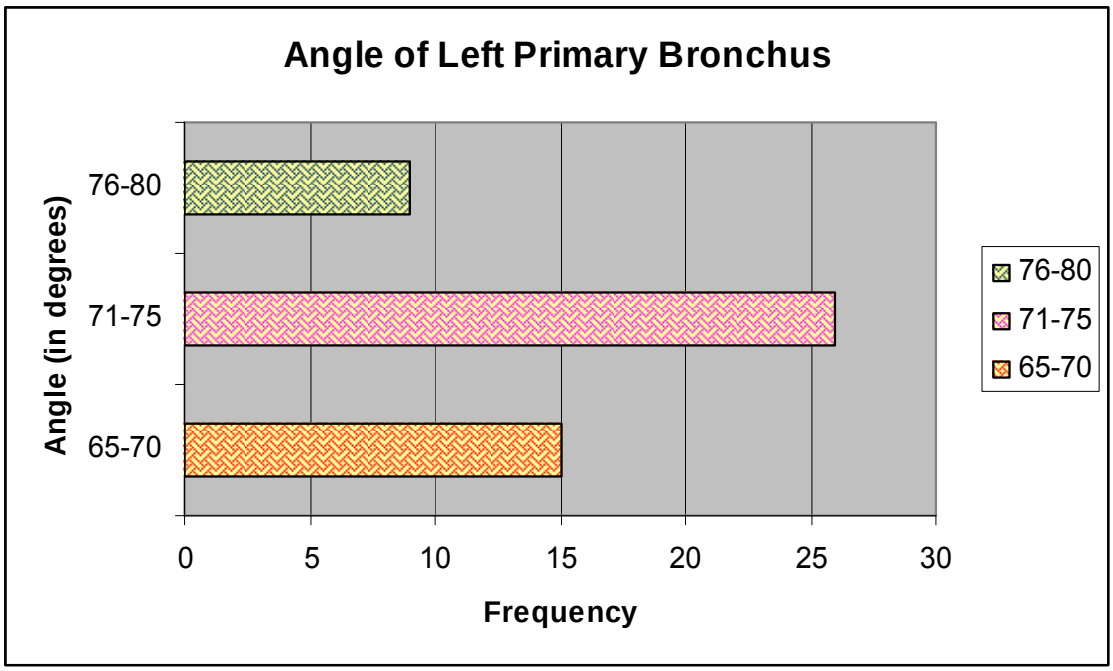
In 14 specimens the length varied from 4.6-5.0cm. Specimen no. 10, 18, 20,..

(b) Angle of Left Primary Bronchus

The angle of left primary bronchus was found to be obtuse in all specimens, varied from 65° to 80° with the average of 74°.

Table No.8

ANGLE (°)	FREQUENCY	SPECIMEN NUMBER
65-70	15	10, 22, 30,..
71-75	26	2, 6, 12,..
76-80	9	4, 8, 14,..



In 15 specimens the angle varied from 65°-70°. Specimen No. 10, 22, 30,..

In 26 specimens the angle varied from 71°-75°. Specimen no. 2, 6, 12,..

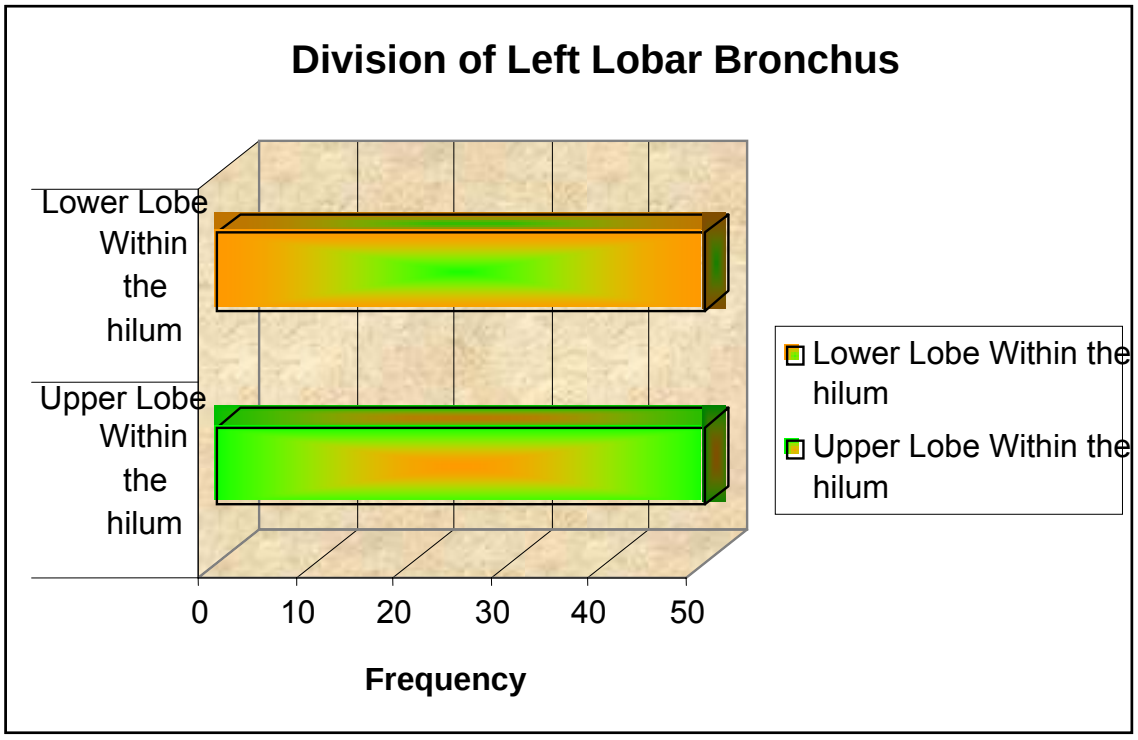
In 9 specimens the angle varied from 76°-80°. Specimen no. 4, 8, 14,..

(c) Division of Left Lobar Bronchus

The left lobar bronchus divides within the hilum into upper and lower lobe bronchus in all specimens.

Table No.9

DIVISION OF LOBAR BRONCHUS	SITE OF DIVISION	FREQUENCY
Upper Lobe	Within the hilum	50
Lower Lobe	Within the hilum	50



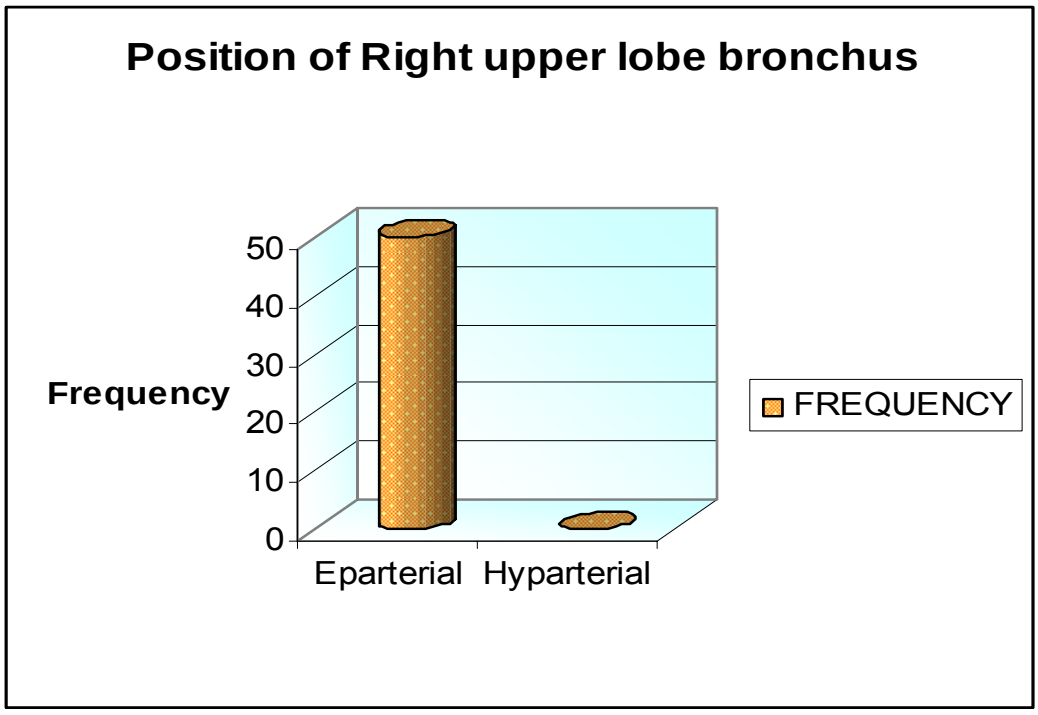
IV. RIGHT UPPER LOBE

(a) Position of Bronchus

The position of right upper lobe bronchus was eparterial in all specimens.

Table No.10

POSITION	FREQUENCY
Eparterial	50
Hyparterial	0

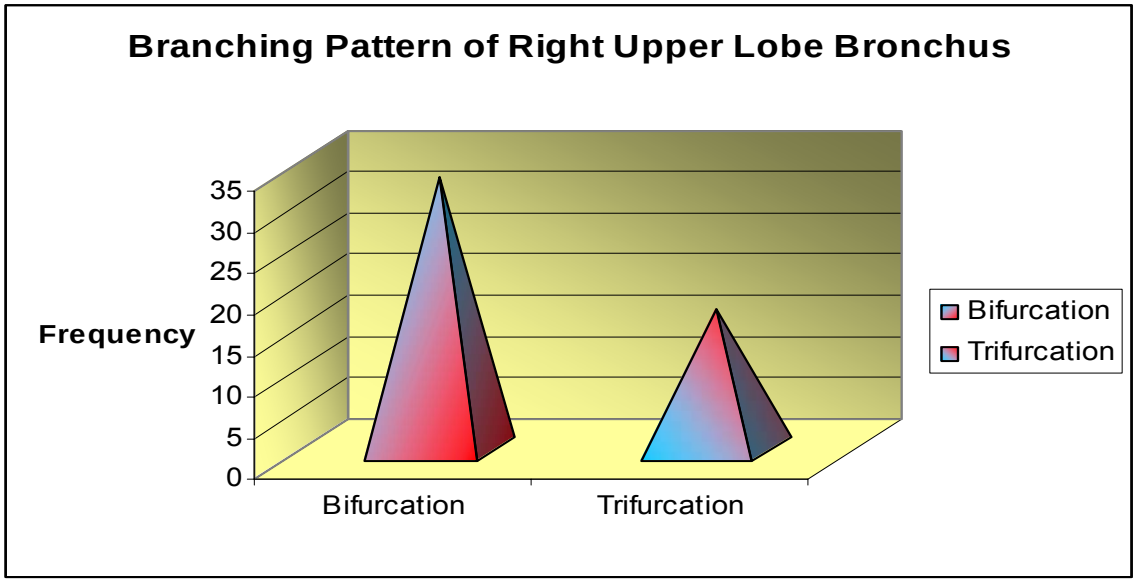


(b) Branching Pattern of Right Upper Lobe Bronchus

The branching pattern of right upper lobe bronchus was found to be both bifurcation and trifurcation with the average percentage of 66 and 34 respectively.

Table No.11

BRANCHING PATTERN	FREQUENCY	SPECIMEN NO.
Bifurcation	33	1, 3, 7,..
Trifurcation	17	5, 13, 17,..



In 33 specimens the branching pattern was bifurcation. Specimen no. 1, 3, 7,..

In 17 specimens the branching pattern was trifurcation. Specimen no. 5, 13, 17,..

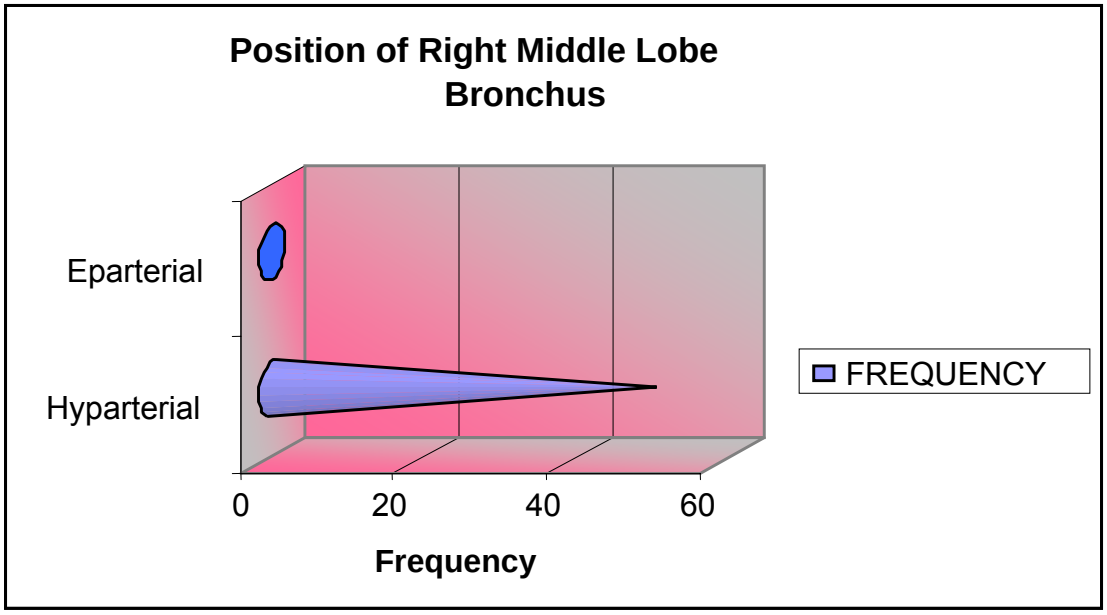
V. RIGHT MIDDLE LOBE BRONCHUS

(a) Position of Right Middle Lobe Bronchus

The position of right middle bronchus was hyparterial in all specimens.

Table No.12

POSITION OF BRONCHUS	FREQUENCY
Hyparterial	50
Eparterial	0

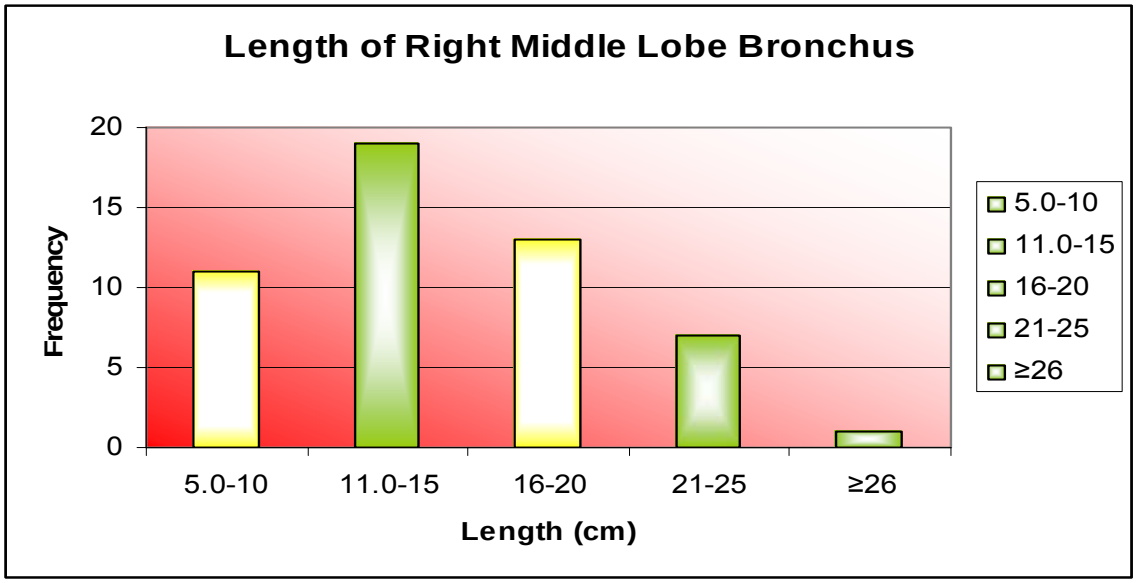


(b) Length of Right Middle Lobe Bronchus

The length of right middle lobe bronchus was found to vary from 5mm to 28mm with the average of 55mm.

Table No.13

LENGTH	FREQUENCY	SPECIMEN NO.
5.0-10	11	11, 19, 23,..
11.0-15	19	1, 5, 7,..
16-20	13	3, 9, 17,..
21-25	7	21, 49, 59,..
≥26	1	67



In 11 specimens the length varied from 5-10mm. Specimen no. 11, 19, 23,..

In 19 specimens the length varied from 11-15mm. Specimen no. 1, 5, 7,..

In 12 specimens the length varied from 16-20mm. Specimen no. 3, 9, 17,..

In 7 specimens the length varied from 21-25mm. Specimen no. 21, 49, 59,..

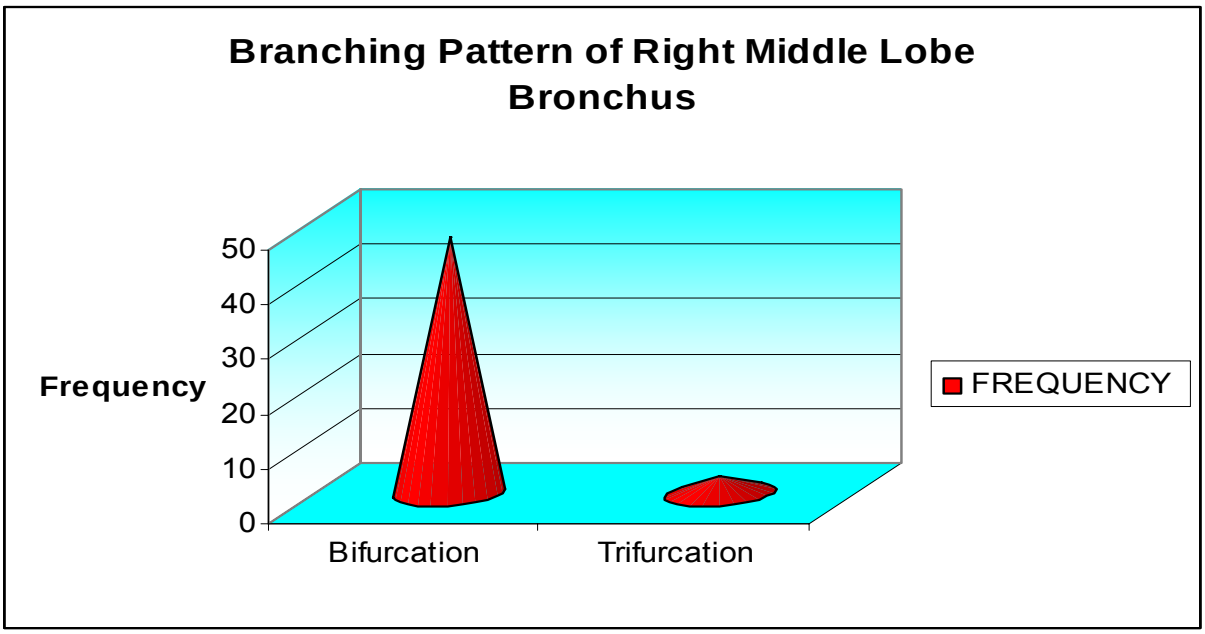
In one specimen the length was above 26mm. Specimen no. 67

(c) Branching Pattern of Right Middle Lobe Bronchus

The branching pattern of right middle lobe bronchus was both bifurcation and trifurcation with the average of 94% and 6% respectively,

Table No.14

BRANCHING PATTERN	FREQUENCY	SPECIMEN NO.
Bifurcation	47	1, 3, 5,..
Trifurcation	3	11, 43, 79,..



In 47 specimens the branching pattern was bifurcation. Specimen no. 1, 3, 5,..

In 3 specimens the branching pattern was trifurcation. Specimen no. 11, 43, 79,..

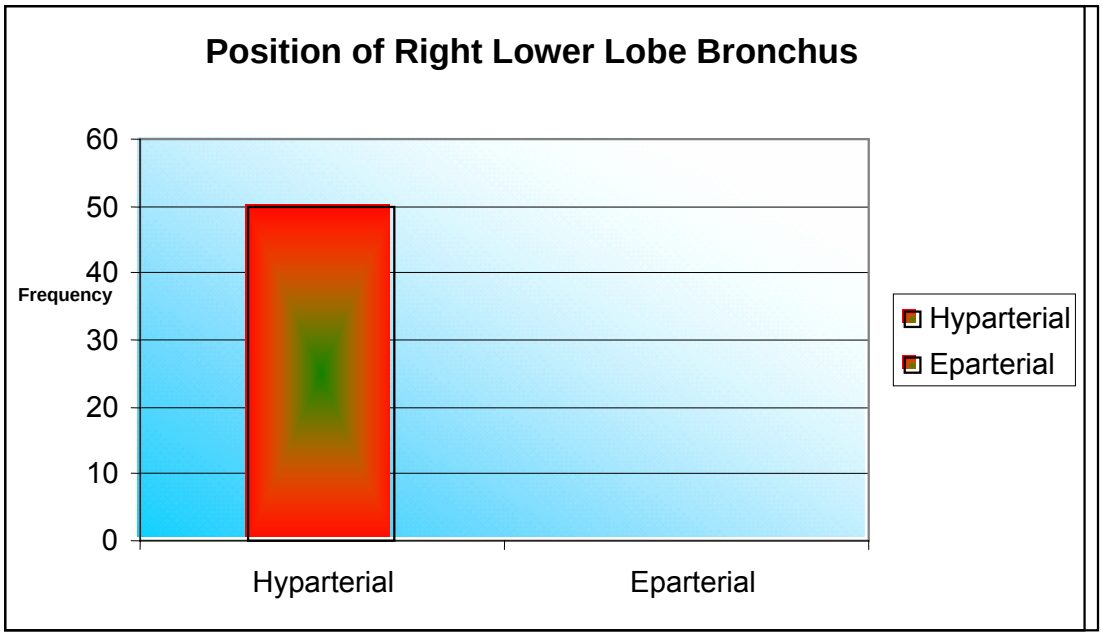
VI. RIGHT LOWER LOBE BRONCHUS

(a) Position of Right Lower Lobe Bronchus

The position of right lower lobe bronchus was hyparterial in all specimens.

Table No.15

POSITION OF BRONCHUS	FREQUENCY
Hyparterial	50
Eparterial	0

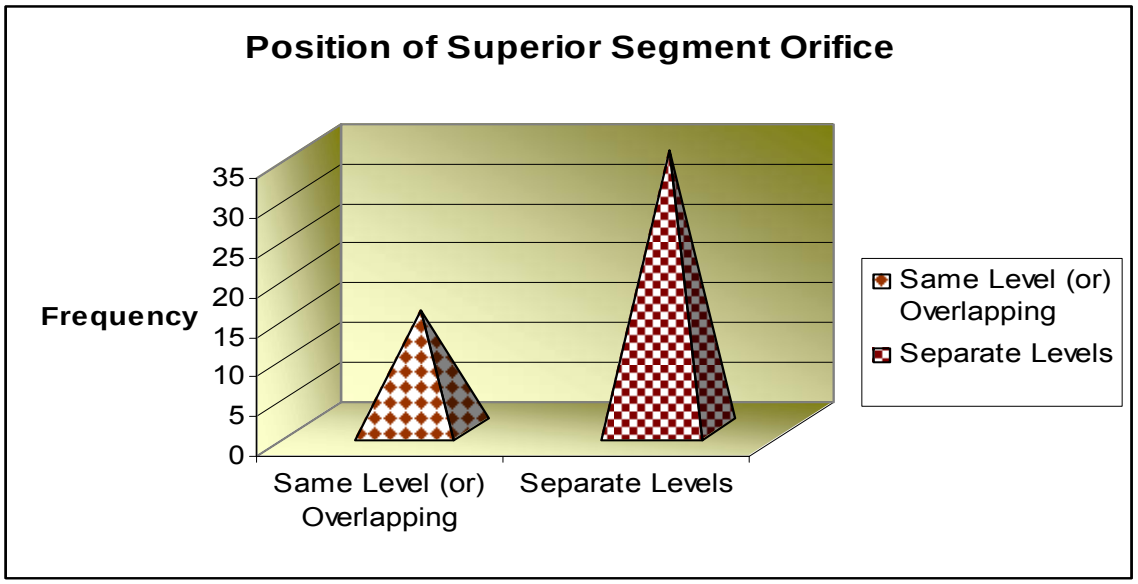


(b) Position of Superior Segment Orifice

The position of superior segment orifice was at the same level or at separate levels with the average of 30% and 70% respectively.

Table No.16

POSITION	FREQUENCY	SPECIMEN NO.
Same Level (or) Overlapping	15	1, 9,15, ..
Separate Levels	35	3, 5, 7,..



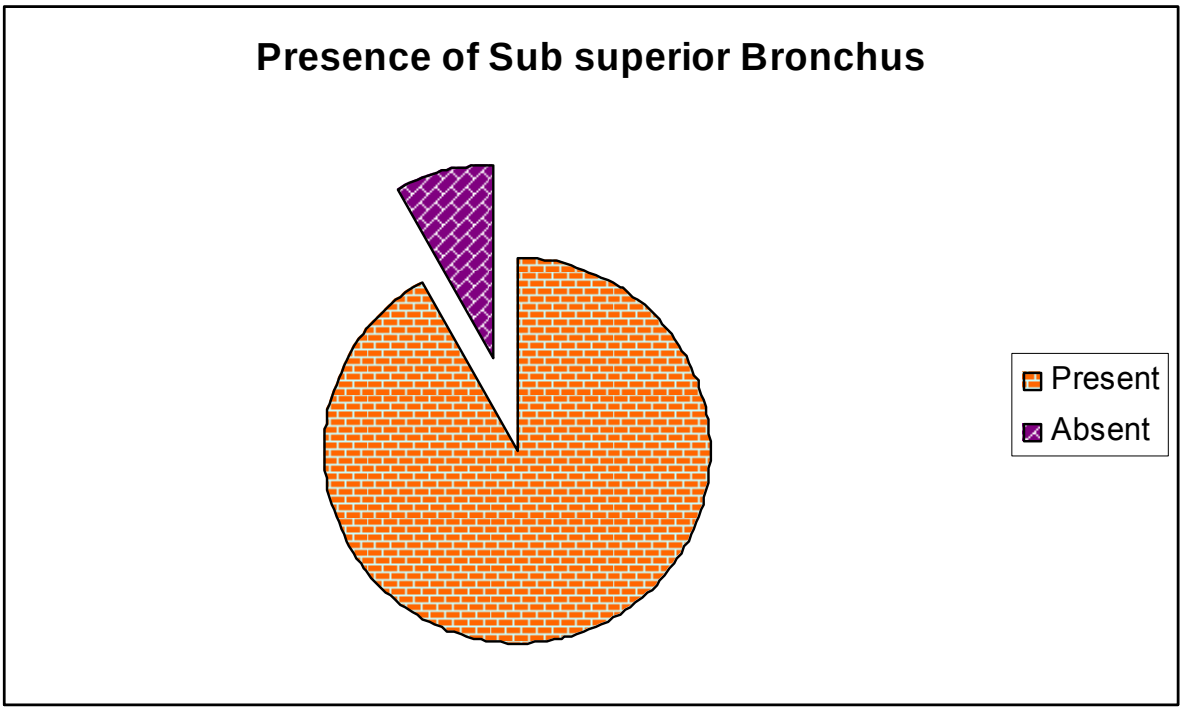
In 15 specimens the superior segment orifice was at the same level or overlapping. Specimen no. 1,9, 15, ..

In 35 specimens the superior segment orifice was at separate levels. Specimen no. 3, 5, 7,..

(c) Presence of Subsuperior Bronchus

Table No.17

SUBSUPERIOR	FREQUENCY	SPECIMEN NO.
Present	46	1, 3, 5,..
Absent	4	17, 37, 81, 93,..



In 46 specimens the subsuperior bronchus was present in the right lower lobe. Specimen no. 1, 3, 5,..

In 4 specimens the subsuperior bronchus was absent in the right lower lobe. Specimen no. 17, 37, 81, 93,..

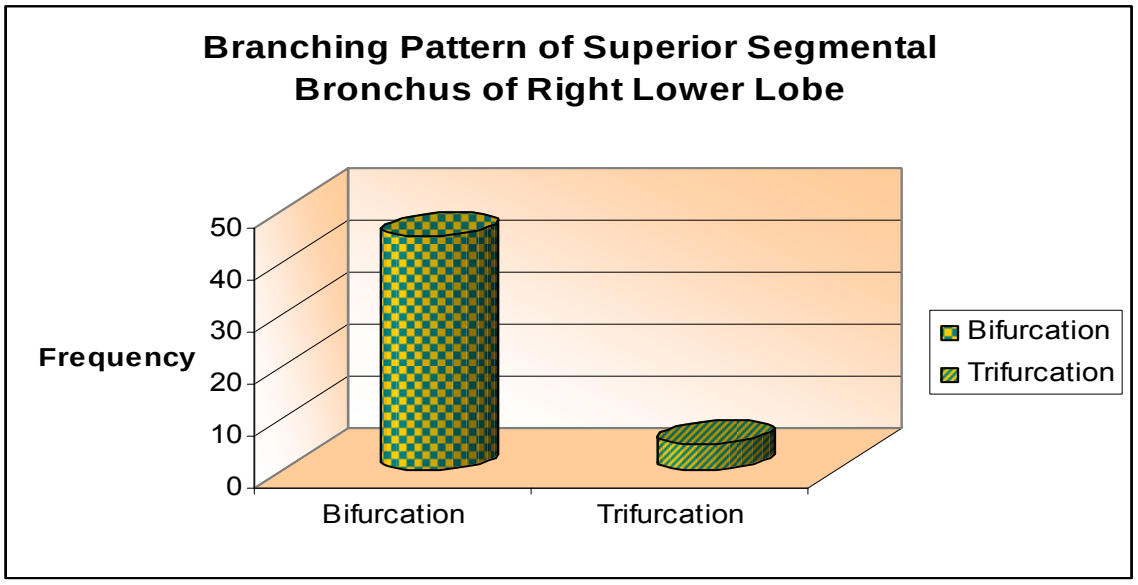
The average presence of subsuperior bronchus was 92%.

The average absence of subsuperior bronchus was 8%.

(d) Branching Pattern of Superior Segmental Bronchus of Right Lower Lobe

Table No.18

BRANCHING PATTERN OF SUPERIOR SEGMENTAL BRONCHUS	FREQUENCY	SPECIMEN NO.
Bifurcation	45	1, 3, 5,..
Trifurcation	5	15, 27, 39,..



The branching pattern of superior segmental bronchus of right lower lobe was bifurcation in 90% and trifurcation in 10%.

In 45 specimens the branching pattern of superior segmental bronchus of right lower lobe was bifurcation. Specimen no. 1, 3, 5,..

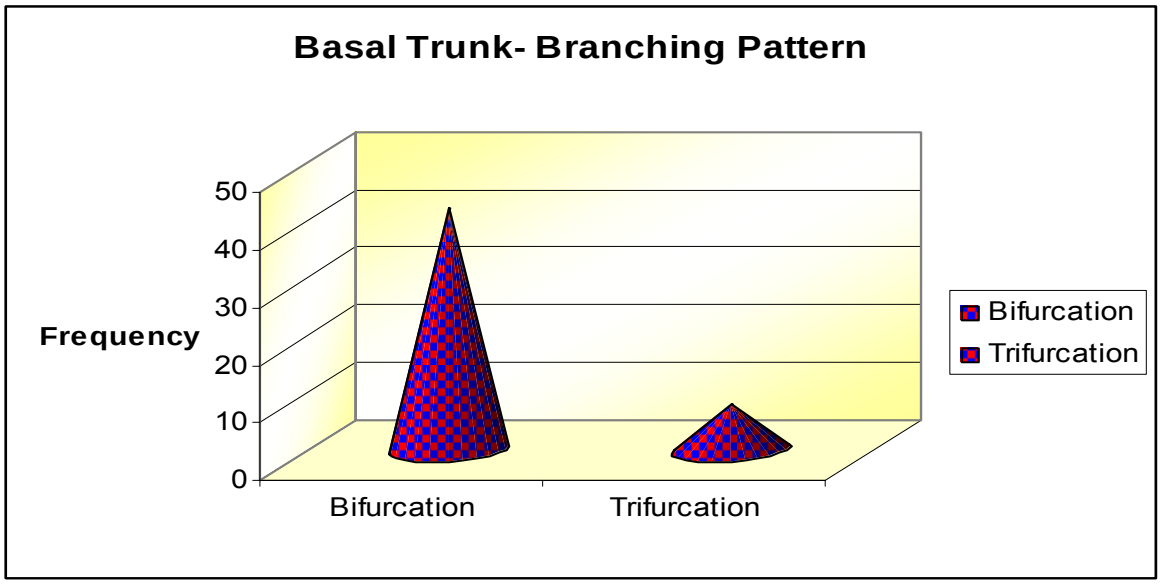
In 5 specimens the branching pattern of superior segmental bronchus of right lower lobe was trifurcation. Specimen no. 15, 27, 39,..

(e) Basal Trunk- Branching Pattern

The branching pattern of basal trunk of right lower lobe was found to be both bifurcation and trifurcation with average of 84% and 16% respectively.

Table No.19

BRANCHING PATTERN	FREQUENCY	SPECIMEN NO.
Bifurcation	42	1,3,5…
Trifurcation	8	15,27,39…



In 42 specimens the branching pattern was bifurcation. Specimen no. 1,3,5…

In 8 specimens the branching pattern was trifurcation. Specimen no. 15,27,39…

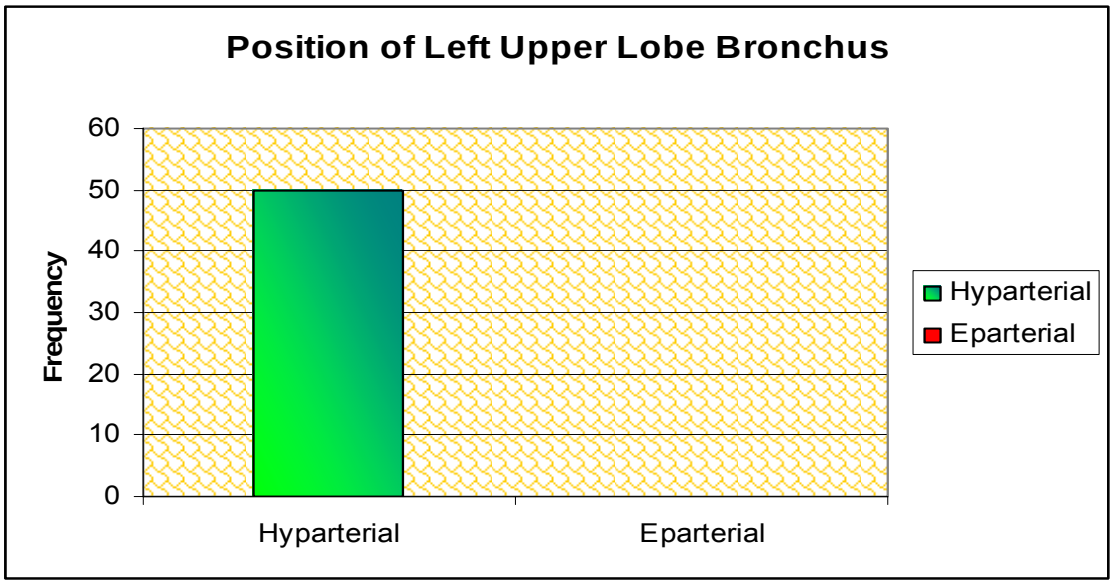
VII. LEFT UPPER LOBE

(a) Position of Left Upper Lobe Bronchus

The position of left upper lobe bronchus was hyparterial in all specimens.

Table No.20

POSITION OF BRONCHUS	FREQUENCY
Hyparterial	50
Eparterial	0

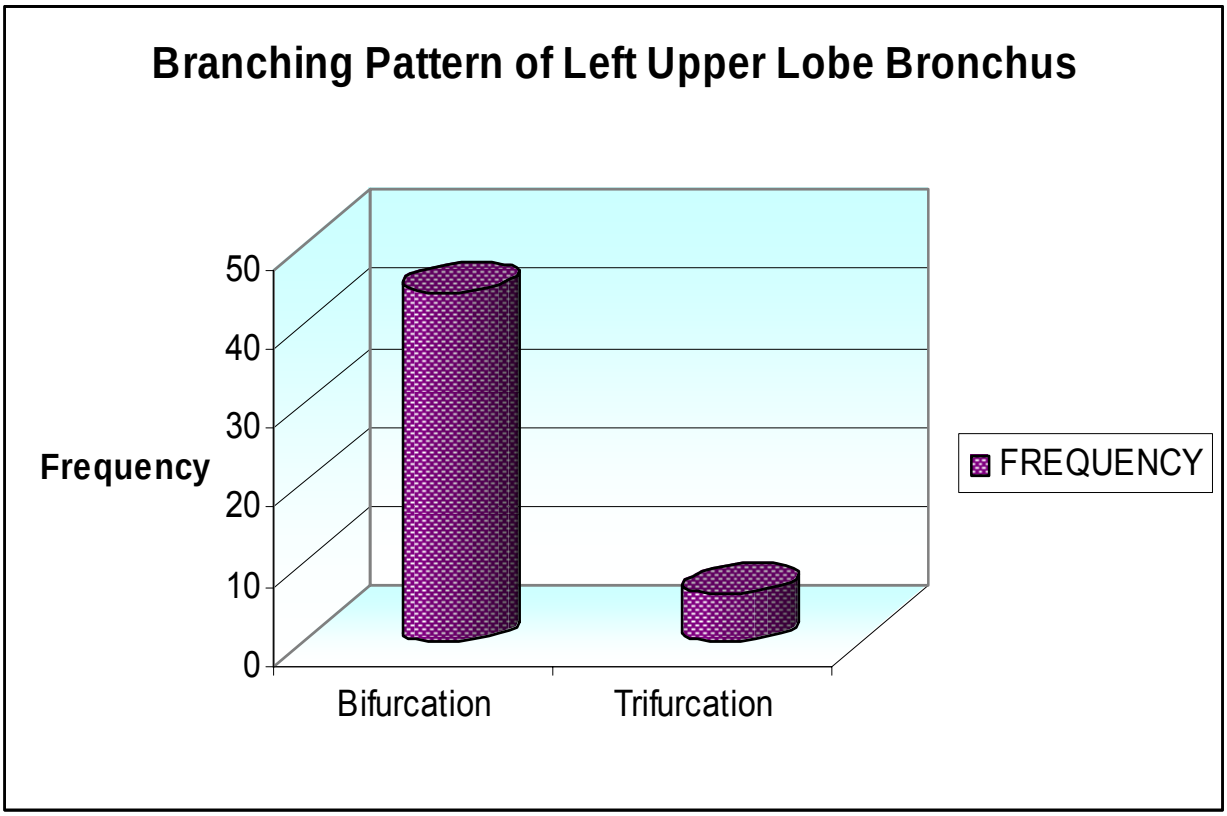


(b) Branching Pattern of Left Upper Lobe Bronchus

The branching pattern of left upper lobe bronchus was bifurcation with the average of 88% and trifurcation with the average of 12%.

Table No.21

BRANCHING PATTERN	FREQUENCY	SPECIMEN NO.
Bifurcation	44	2,6, 8..
Trifurcation	6	4, 14,18..



In 44 specimens branching pattern of left upper lobe bronchus was bifurcation. Specimen no. 2,6, 8..

In 6 specimens branching pattern of left upper lobe bronchus was trifurcation. Specimen no. 4,14,18..

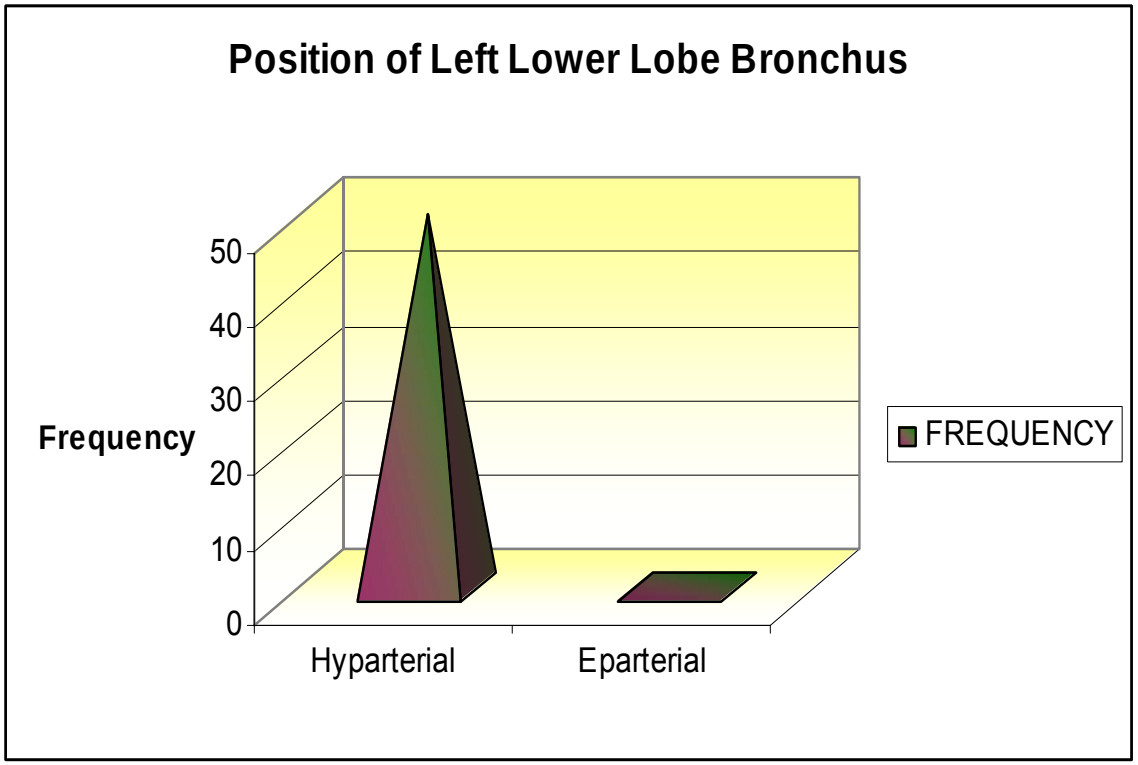
VIII. LEFT LOWER LOBE BRONCHUS

(a) Position of Bronchus

The position of left lower lobe bronchus was found to be hyparterial in all specimens.

Table No.22

POSITION OF BRONCHUS	FREQUENCY
Hyparterial	50
Eparterial	0

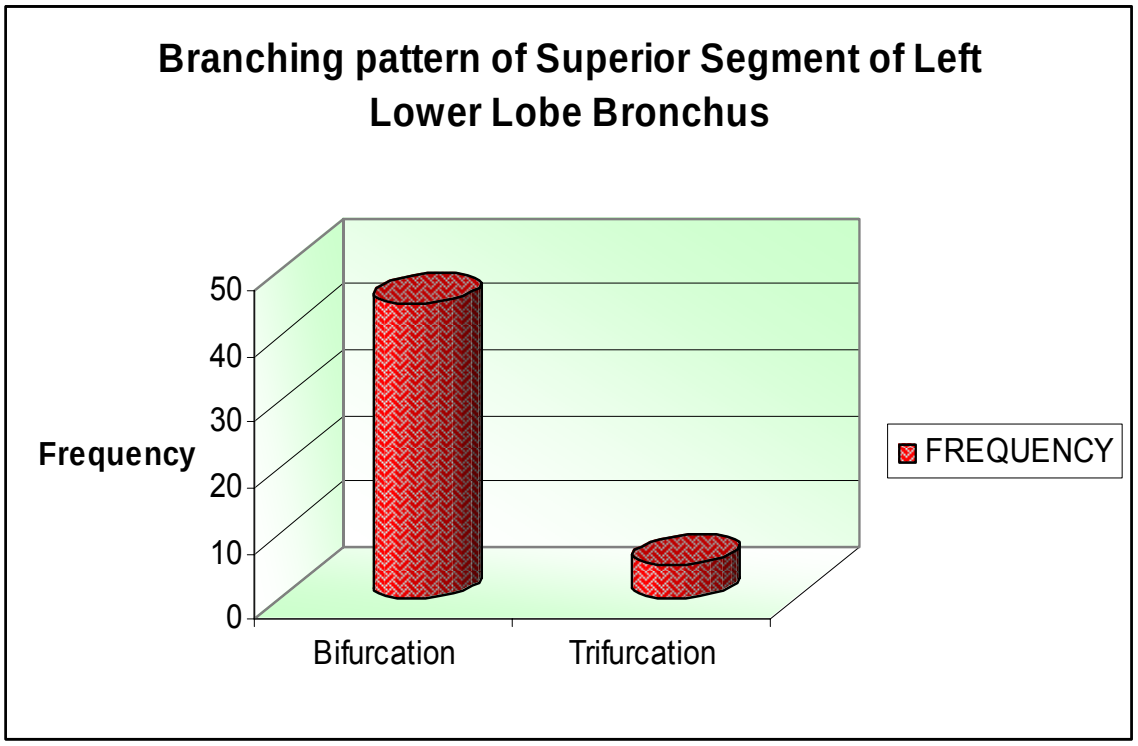


(b) Branching pattern of Superior Segment of Left Lower Lobe Bronchus

The branching pattern of superior segment of left lower lobe bronchus was found to be bifurcation with the average of 90% and trifurcation with the average of 10%.

Table No.23

BRANCHING PATTERN	FREQUENCY	SPECIMEN NO.
Bifurcation	45	2, 4, 6,..
Trifurcation	5	42, 50, 64,..



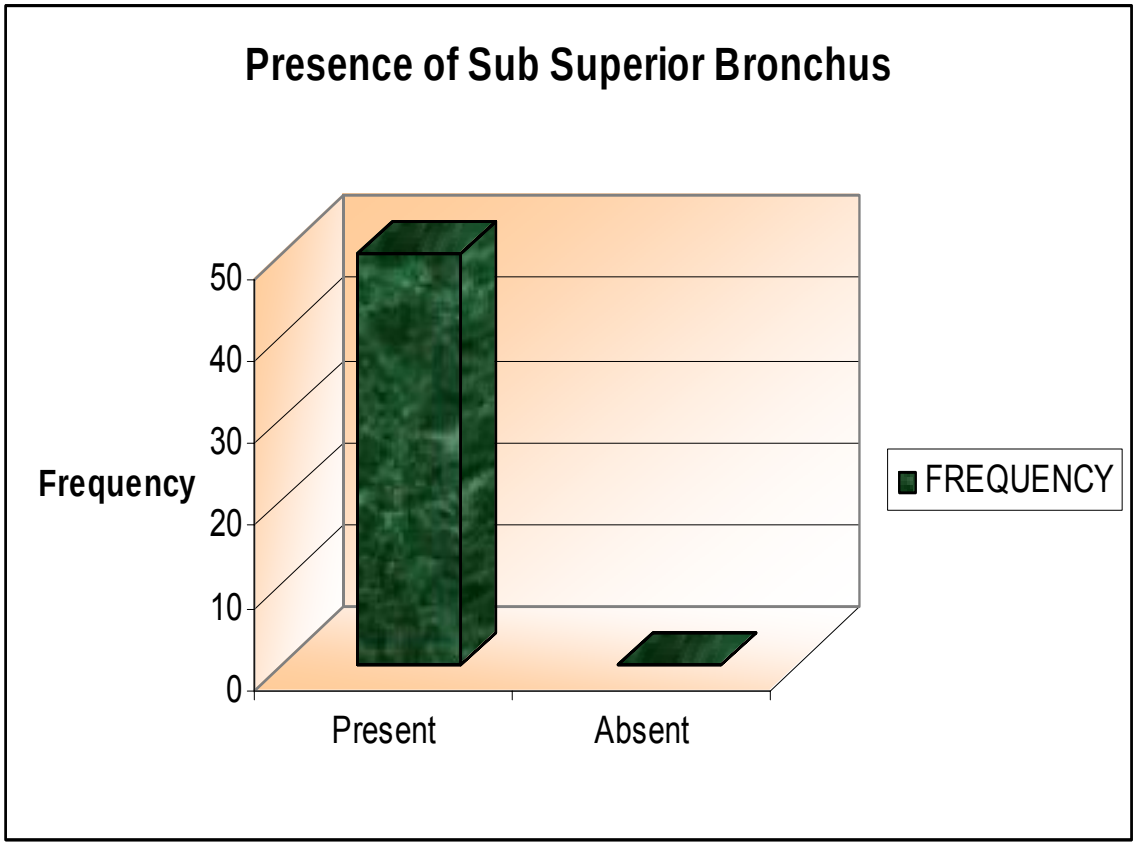
In 45 specimens the branching pattern was bifurcation. Specimen no. 2, 4, 6,..

In 5 specimens the branching pattern was trifurcation. Specimen no. 42, 50, 64,..

(c) Presence of Subsuperior Bronchus

Table No.24

SUBSUPERIOR	FREQUENCY
Present	50
Absent	0



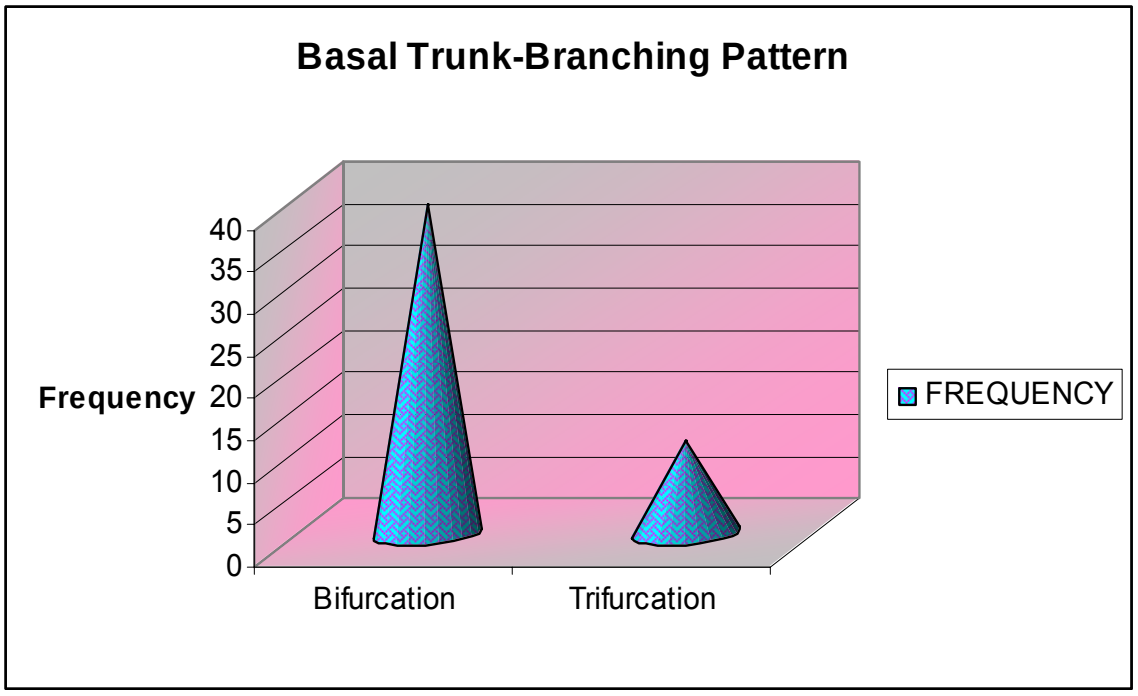
The subsuperior bronchus was present in all specimens.

(d) Basal Trunk-Branching Pattern

The branching pattern of basal trunk of left lower lobe was bifurcation with the average of 78% and trifurcation with the average of 22%.

Table No.25

BRANCHING PATTERN	FREQUENCY	SPECIMEN NO.
Bifurcation	39	4, 8,10,
Trifurcation	11	2, 6, 14,..



In 39 specimens the branching pattern was bifurcation. Specimen no. 4, 8, 10,..

In 11 specimens the branching pattern was trifurcation. Specimen no. 2, 6, 14,..

DISCUSSION

The present study on the tracheo bronchial tree in 50 pairs of specimens is compared with earlier studies and discussed.

1. Dimensions of Trachea

(a) Diameter of Trachea

Cunningham (1972) described that the diameter of trachea is 2cm in adult male, rather less in adult female.

Richard S.Snell (1993) described that the trachea is 2.5cm in diameter.

Last (1996) described that the trachea is 2cm in diameter.

Peter L.Williams in Gray's Anatomy (2000) described that the diameter of trachea is 2cm in adult male and 1.5cm in adult female.

In the present study the diameter of trachea was found to vary from 1.3cm to 2.6cm with the average of 2.10cm.

(b)Length of Trachea

William E.Bloomer (1889) described that the trachea is 11cm long.

W.Henry Hollinshead (1966) described that the length of trachea is 18mm.

Cunningham (1972) described that the length of trachea is 9-15cm in adult.

Richard S.Snell (1993) described that the trachea is 13cm in length.

Last (1996) described that the tracheal length is 10cm.

Peter L.Williams in Gray's Anatomy (2000) described that the length of trachea is 10-11cm.

In the present study the length of the trachea was found to vary from 6.5cm to 16cm with the average of 11.20cm.

(C) Number of Tracheal Rings

Cunningham (1972) described that the number of tracheal rings is15-20.

Cecil (2000) described that the number of tracheal rings is 15-20.

Harold Ellis (2002) described that the number of tracheal rings is from15-20.

In the present study, the number of tracheal rings was found to vary from 14 to 22 with the average of 18.

II. Right Primary Bronchus

(a) Length of Right Primary Bronchus

Aeby (1880) measured the length of right primary bronchus as 2.3cm (with a range of 1.5 to 3.4)

W.Henry Hollinshead (1966) described that the length of right primary bronchus is 2.5cm.

Cunningham (1972) described that the right primary bronchus length is 2.5cm.

According to Gray's anatomy (2000) the right main bronchus is 2.5cm long.

In the present study the length of right main bronchus was found to vary from 1.0cm to 3.0cm, with the average length of 2.0cm.

(b) Angle of Right Main Bronchus

Heinrich Von Hayek (1960) described that in case of longer bronchus the angle between two bronchus is mostly more acute.

W.Henry Hollinshead (1966) described that the right bronchus forms an angle of about 25° with the midline.

J.G.Scadding, Gordon Cumming (1981) described that the angle of right main bronchus is 35°

In the present study the angle of right main bronchus was found to vary from 20° to 50° with the average of 37°.

(c) Division of Right Lobar Bronchus

Richard S.Snell (1993) described that before entering the hilum of right lung the principal bronchus gives off superior lobar bronchus. On entering the hilum it divides into a middle and inferior lobar bronchus.

R.M.H. Mc Minn (1966) in Last's Anatomy described that the right main bronchus gives off the upper lobe bronchus outside the hilum and ends within the hilum into upper and lower lobar bronchus.

Peter L.Williams (2000) in Gray's Anatomy described that the right superior lobar bronchus, about 1cm from its origin divides into 3 segmental bronchus.

In the present study in all specimens the right main bronchus gives off superior lobar bronchus before entering the hilum. On entering the hilum it divides into a middle and inferior lobar bronchus.

III.LEFT PRIMARY BRONCHUS

(a) Length of Left Primary Bronchus

Aeby (1880) measured the length of left primary bronchus as 5.5cm (with a range of 4.3 to 5.8 cm).

W.Henry Hollinshead (1966) described that the length of left bronchus is 4 to 5cm.

Cunningham (1972) described that the left main bronchus is about 5cm long.

According to Gray's Anatomy (2000) the left principal bronchus is 5cm long.

In the present study the length of left main bronchus was found to vary from 3.5 to 5cm with the average of 4.4cm.

(b)Angle of Left Main Bronchus

J.G.Scadding, Gordon Cumming (1981) described that the angle of left main bronchus is 73°.

C.John Gibson, Duncan M.Geddes, Ulrich Costabel, Peter J.Sterk, Bryan Corrin (2003) described that the left main bronchus makes an angle of about 70° with that of the trachea.

In the present study the angle of left main bronchus varies from 65° to 80° with the average angle of about 74°.

(c)Division of Left Lobar Bronchus

Richard S.Snell (1993) described that on entering the hilum of left lung the main bronchus divides into a superior and an inferior lobar bronchus.

R.M.H Mc Minn (1966) in Last's Anatomy described that the left main bronchus divides within the hilum into upper and lower lobe bronchus.

In the present study in all specimens the left main bronchus divides within the hilum into upper and lower lobe bronchus.

IV.RIGHT UPPER LOBE BRONCHUS

(a) Position of Right Upper Lobe Bronchus

Boyden and Hartmann (1946) described a case in which only the apical branch of right upper lobe bronchus laid eparterially.

Heinrich Von Hayek (1960) described that the right pulmonary artery crosses caudal to right upper lobe bronchus and so this is called as eparterial bronchus.

In the present study all the right upper lobe bronchi were placed eparterially.

(b)Branching Pattern of Right Upper Lobe Bronchus

Edward A.Boyden (1955) described that the right upper lobe trifurcates in 46% and bifurcates in 54%.

William E.Bloomer (1960) described that in right upper lobe trifurcation occurred in 52% and double bifurcation in 48%.

R.M.H.Mc Minn (1966) in Last's Anatomy described that the right upper lobe bronchus has three segments.

Peter L.Williams (2000) in Gray's Anatomy described that the right superior lobar bronchus divides into 3 segmental bronchus.

In the present study the branching pattern of right upper lobe bronchus was trifurcation in 34 % and bifurcation in 66%.

V.RIGHT MIDDLE LOBE

(a)Length of Right Middle Lobe Bronchus

Edward A.Boyden (1955) described that the length of right middle lobe bronchus is 18mm (range 12 to 26mm).

William E.Bloomer (1960) described that the length of right middle lobe bronchus is 8 to 25mm, average is 13mm.

W.Henry Hollinshead (1966) described that the length of right middle lobe bronchus is 18mm.

In the present study the length of right middle lobe bronchus varied from 5mm to 28mm with the average of 15mm.

(b)Branching Pattern of Right Middle Lobe Bronchus

Edward A.Boyden (1955) described that the right middle lobe bronchus bifurcates in 98% and trifurcates 2%.

William E.Bloomer (1960) described that in the right middle lobe bronchus bifurcation occurs in 96% and trifurcation in 4%.

W.Henry Hollinshead (1966) described that the right middle lobe bronchus usually bifurcates but in 2 to 3 % trifurcation occurs.

In the present study the branching pattern of right middle lobe bronchus both bifurcation and trifurcation occurs with the average of 94% and 6% respectively.

VI.RIGHT LOWER LOBE

(a)Position of Superior Segment Orifice

Edward A.Boyden (1955) described that bronchoscopically its orifice is situated first inferior to the orifice of middle lobe bronchus and nearly opposite to it.

William E.Bloomer (1960) described that the bronchial orifices of middle lobar and superior segmental bronchi of lower lobe may be at the same level or overlap in 18% or at adjacent levels in 10% or at separate levels in 72%. In no instance apical bronchus takes origin at a level higher than that of middle lobe bronchus.

W.Henry Hollinshead (1966) described that in right lung the origin of superior segmental bronchus to lower lobe and middle lobe bronchus are at the same level or only a few mm apart.

In the present study the position of orifice of superior segmental bronchi of right lower lobe is overlapping or at same level in 30% and at separate levels in 70%.

(b)Branching Pattern of Superior Segmental Bronchus of Right Lower Lobe

Edward A.Boyden (1955) described that the superior segmental bronchus arises as a single stem bifurcates in 89%, trifurcates in 5%. The superior segment arises as two separate stems in 6%.

William E.Bloomer (1960) described that the superior segmental bronchus of right lower lobe arises as a single stem bifurcates into 74%, trifurcates into 16%. This arises as two separate stems in 8% and arises as three separate stems in 2 %.

In the present study the superior segmental bronchus arises as a single stem bifurcates in 90%, trifurcates in 10%.

(c)Subsuperior Bronchus

According to Brock (1943) in 61% of 100 dissected specimens, subsuperior and accessory subsuperior bronchus present in 48% of 50 specimens. The distribution of accessory subsuperior in the absence of subsuperior is 38%. The prevailing pattern is both subsuperior and accessory subsuperior present in the same specimen is 45%.

William E.Bloomer (1960) described that a subsuperior or an accessory subsuperior or both present in 98%. In 21% there is a single subsuperior arising from the posterior aspect of basal trunk with no accessory subsuperior arising from the lower level.

Peter L.Williams (2000) in Gray's Anatomy described that in more than half of all right lungs a subsuperior (subapical) segmental bronchus arises posteriorly from the inferior lobar bronchus 1-3cm below the superior segmental bronchus.

In the present study the subsuperior bronchus was present in 92% specimens.

(d)Branching Pattern of Basal Trunk of Right Lower Lobe

Berg, Boyden, Smith (1949) described that in basal trunk bifurcation occurred in 87% and a trifurcation occurred in 13%.

William E.Bloomer, Averill A.Liebow, Milton R.Hales (1960) described that the basal trunk bifurcates in all 50 dissected specimens.

In the present study the basal trunk bifurcates in 84% and trifurcates in 16%.

VII.LEFT UPPER LOBE BRONCHUS

Edward A.Boyden (1955) described that the left upper lobe bronchus bifurcates in 73% and trifurcates in 27%.

William E.Bloomer (1960) described that the left upper lobe bronchus bifurcates into 86% trifurcates into 14%.

W.Henry Hollinshead (1966) described that in left upper lobe bronchus bifurcation occurs in 74% according to Boyden and Hartmann trifurcation in 26%.

In the present study the left upper lobe bronchus bifurcates in 88%, trifurcates in 12%.

VIII.LEFT LOWER LOBE BRONCHUS

(a) Superior Segment-Branching Pattern

Edward A.Boyden (1955) described that the superior segmental bronchus of left lower lobe arises as a single trunk bifurcates into 83.7%, trifurcates into 15.4% arises as two separate trunks in 0.9%.

William E.Bloomer (1960) described that the superior segmental bronchus of left lower lobe arises as a single stem bifurcates into 85% trifurcates into 15%, arises as two independent stems in 0%.

In the present study the superior segmental bronchus of left lower lobe arises as a single stem bifurcates into 90%, trifurcates into 10%.

(b) Presence of Subsuperior Bronchus

Edward A.Boyden (1955) described that the subsuperior occurs much less frequently on the left side 27%, than on the right 61%. The number of specimens in which there is two or more subsuperior is much greater on the left 80% than on right 57%.

William E.Bloomer, Averill A.Liebow, Milton R.Hales (1960) described that the subsuperior or accessory subsuperior bronchi chiefly the latter occur in all left lungs. The subsuperior is represented by single bronchus in 14.5%, by two bronchi in 64.5% and by three bronchi in 20.8%.

In the present study the subsuperior bronchus was present in all left lungs.

(c)Branching Pattern of Basal Trunk of Left Lower Lobe Bronchus

Edward A.Boyden (1955) described that the basal trunk bifurcates in 77.3% and trifurcates in 22.7%.

Berg, Boyden and Smith (1949) described that the basal trunk bifurcates in 87% and trifurcates in 13%.

William E.Bloomer, Averill A.Liebo, Milton R.Hales (1960) described that the basal trunk bifurcates in 96% and trifurcates in 4%.

In the present study the basal trunk bifurcates in 78% and trifurcates in 22%.

The medial basal segment arises as anteromedial segment in 78% and there is no medial basal segment in 22% and the main stem terminates into anterior, lateral and posterior basal segments.

CONCLUSION

In the present study the tracheo bronchial tree was studied and the results were compared with earlier studies.

The summary of the present study in human, in 50 pairs of specimens of both lungs is as follows. The diameter of trachea was within normal limits in about 94%. The length of trachea was within normal limits in about 76%. The number of tracheal rings was within normal limits in about 90%.

The length of the right primary bronchus was within normal limits in about 90%.

The angle of the right primary bronchus was within normal limits in about 90%.

The length of the left primary bronchus was within normal limits in about 94%.

The angle of the left primary bronchus was within normal limits in about 72%.

In the right lung both eparterial and hyparterial bronchus were present. In the left lung only the hyparterial bronchus was present in all specimens.

In the right upper lobe bifurcation occurred in 66%, trifurcation in 34%.

In the right middle lobe length of the middle lobe bronchus was within normal limits in 86%.

In the right middle lobe bifurcation occurred in 94%, trifurcation in 6%

In the right lower lobe superior segment orifice was at same level or overlapping in 30% and at separate levels in 70%.

In the right lower lobe the branching pattern of superior segment was bifurcation in 90% and trifurcation in 10%.

In the right lower lobe the subsuperior bronchus was present in 92%.

In the right lower lobe the branching pattern of basal trunk was bifurcation in 84% and trifurcation in 16% of the specimens.

In the left upper lobe branching pattern was bifurcation in 88%, trifurcation in 12%.

In the left lower lobe superior segment bronchus bifurcated in 90%, trifurcated in 10%.

In the left lower lobe subsuperior bronchus was present in all lungs.

In the left lower lobe the branching pattern of basal trunk was bifurcation in 78%, trifurcation in 22%.

Unfortunately the lung is not simply built. An understanding of its structure can be achieved only by effort. In planning operative procedures that will serve to remove disease, while preserving useful tissue, this effort will be well expended. An attempt at application of the anatomical data is very useful to the planning of the surgical approach.

Pulmonary functions show exactly how essential is the amount of pulmonary tissue for good and efficient functioning of lungs. Therefore the segmental resection can be performed in eligible cases saving valuable lung tissue. To undertake this, detailed anatomy of the segmentation of lungs then becomes inevitable.

This study is presented to shed more light on normal anatomy of trachea and the branching pattern of bronchi.

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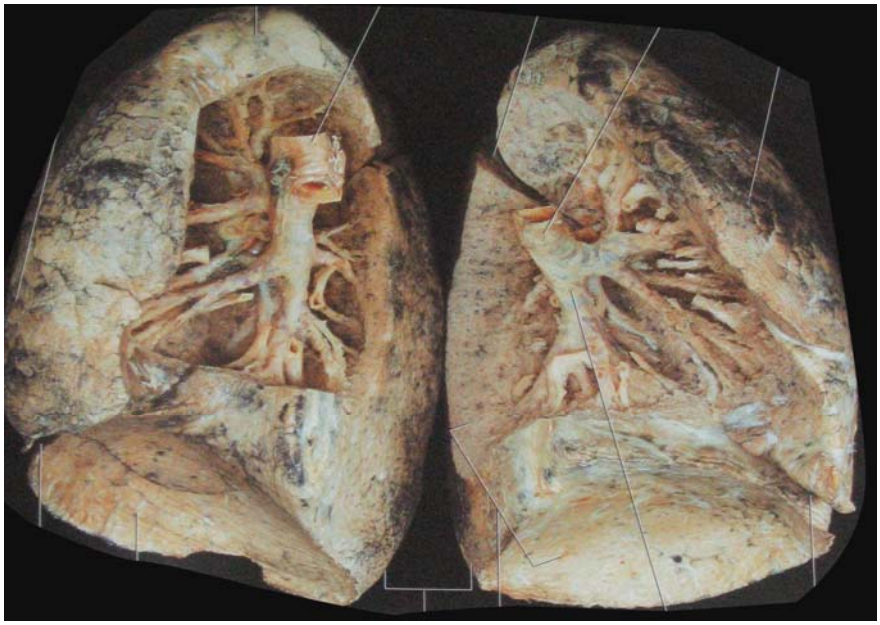
ABBREVIATIONS

BEH	before entering the hilum
OEH	on entering the hilum
Wh	within the hilum
Ep	eparterial
Hyp	hyparterial
RUL	right upper lobe
RML	right middle lobe
RLL	right lower lobe
LUL	left upper lobe
LLL	left lower lobe
Bifur	bifurcation
Trifur	trifurcation

NORMAL LUNGS IN-SITU

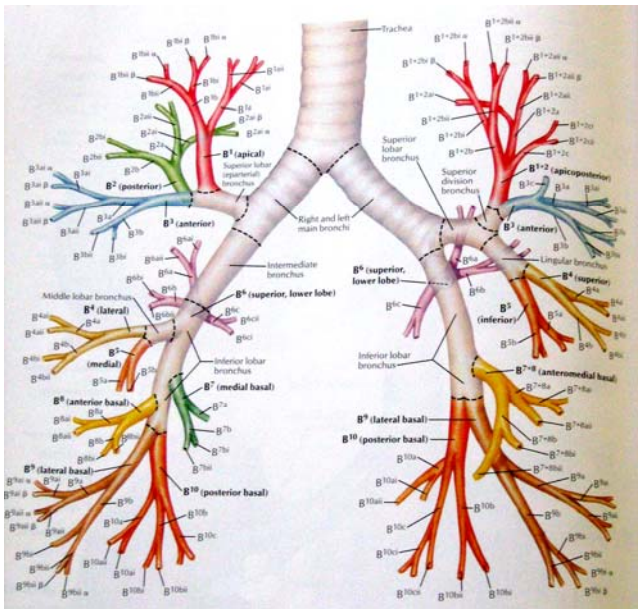


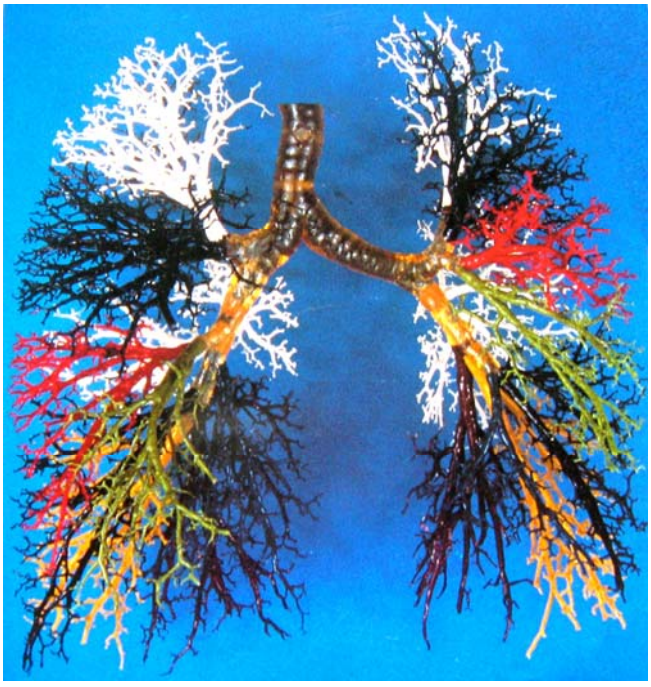
BRONCHIAL TREE OF ISOLATED LUNGS

COSTAL SURFACE – RIGHT LUNG

COSTAL SURFACE – LEFT LUNG

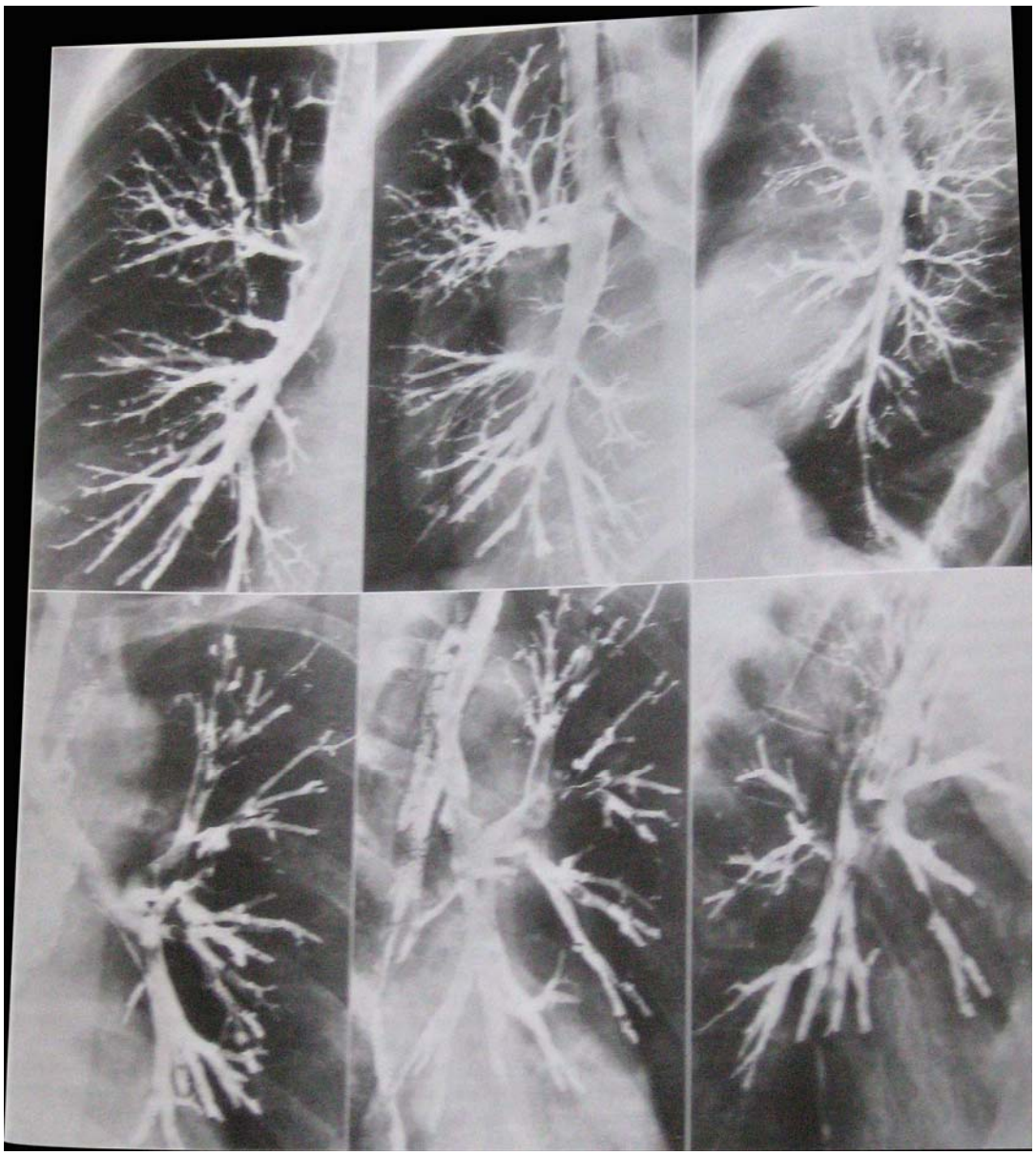
NOMENCLATURE OF BRONCHI-SCHEMA





RESIN CORROSION CAST

BRONCHOGRAPHY



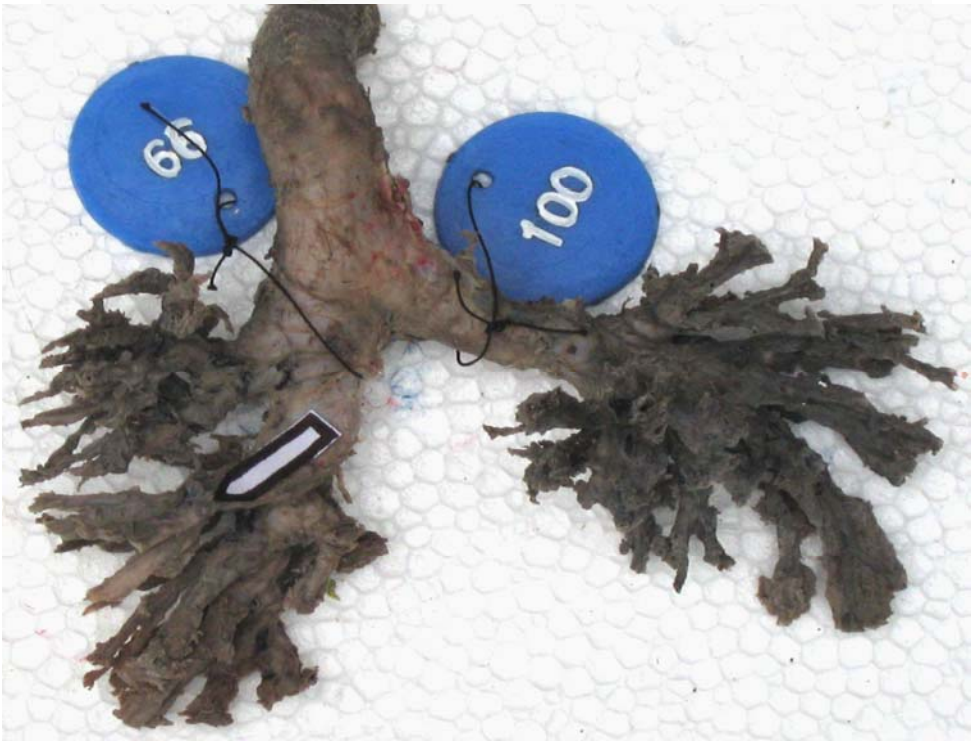
NORMAL TRACHEO BRONCHIAL TREE-ANTERIOR ASPECT

NORMAL TRACHEO BRONCHIAL TREE-POSTERIOR ASPECT

RIGHT UPPER LOBE - TRIFURCATION

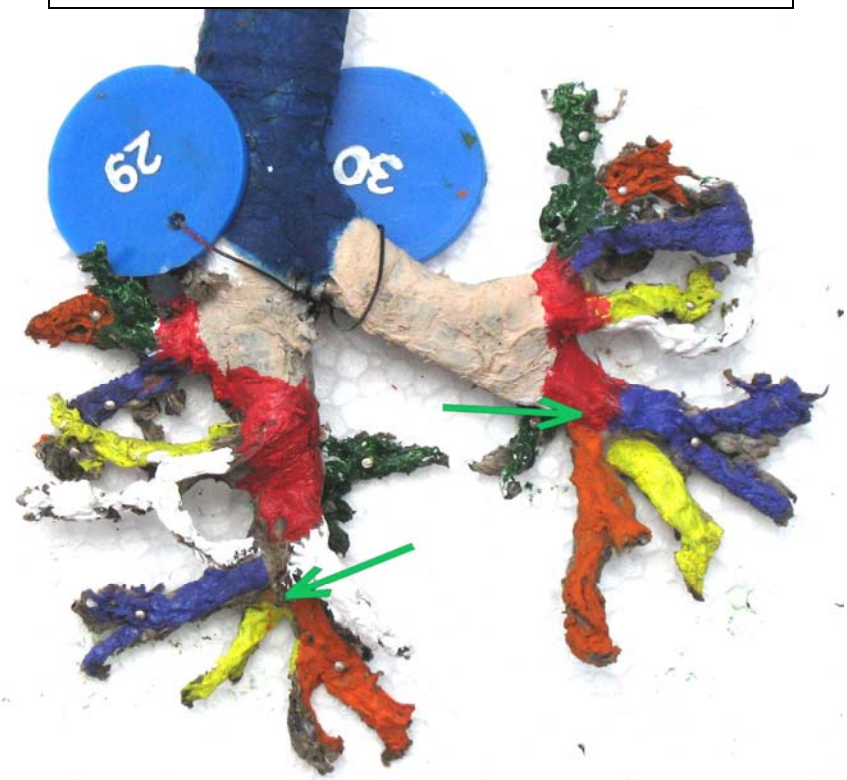
RIGHT UPPER LOBE - BIFURCATION

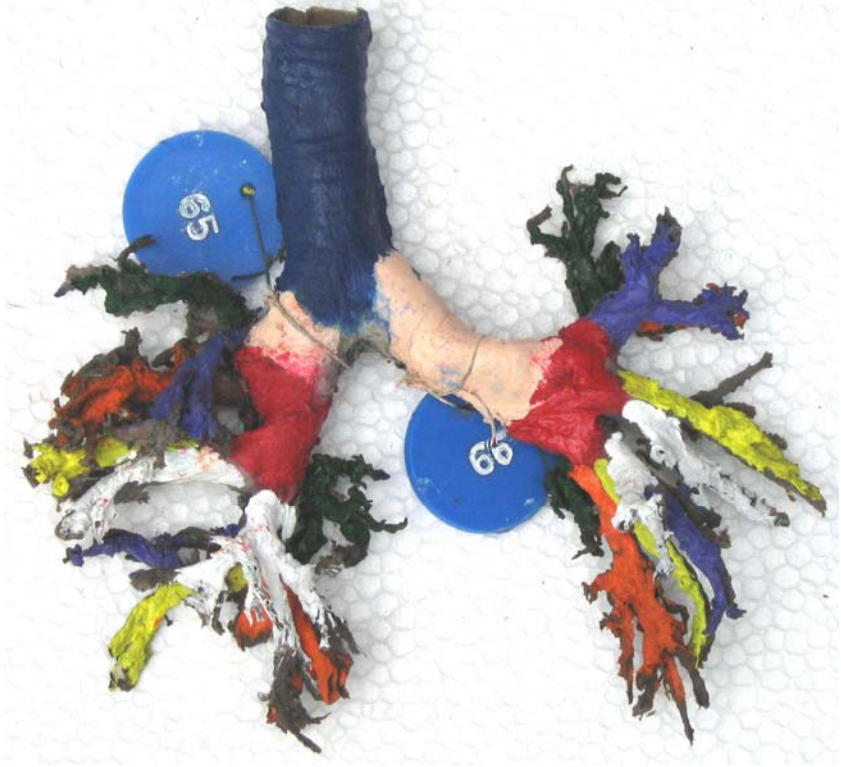
RIGHT MIDDLE LOBE - BIFURCATION



RIGHT MIDDLE LOBE - TRIFURCATION

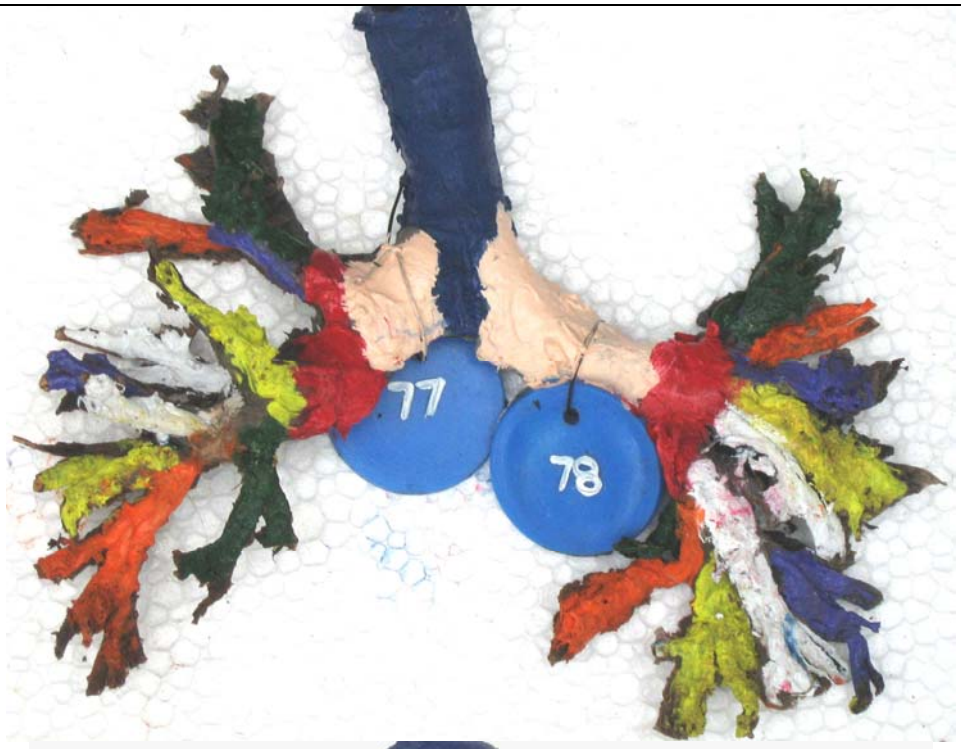
BOTH LOWER LOBES - TRIFURCATION

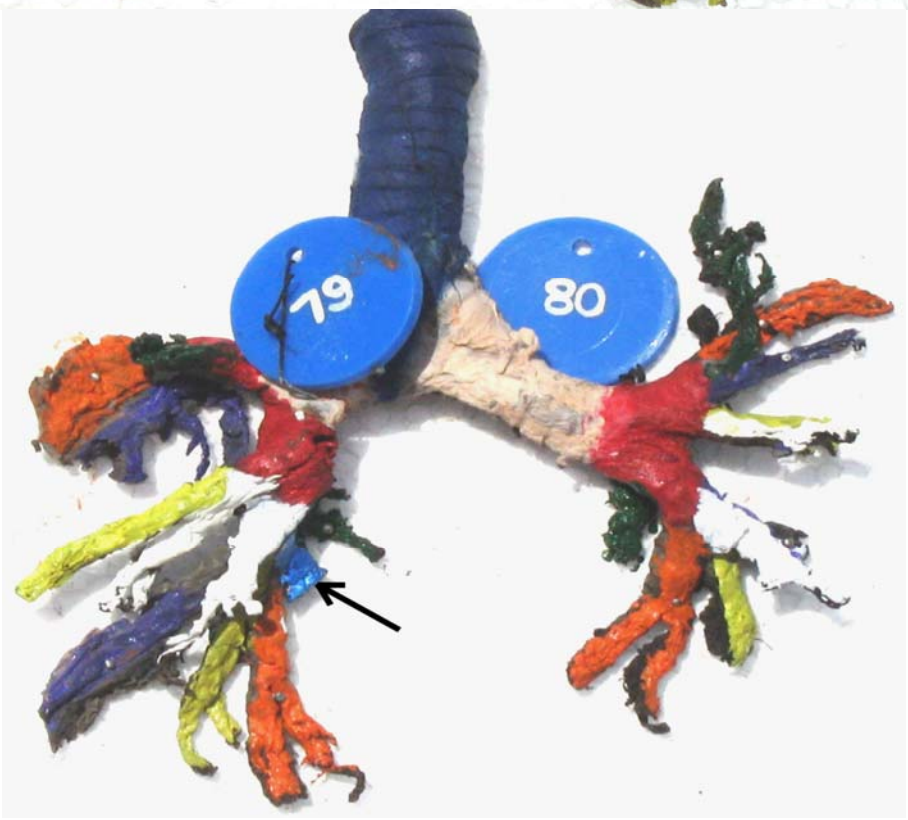




RIGHT LOWER LOBE SUPERIOR SEGMENT - TRIFURCATION

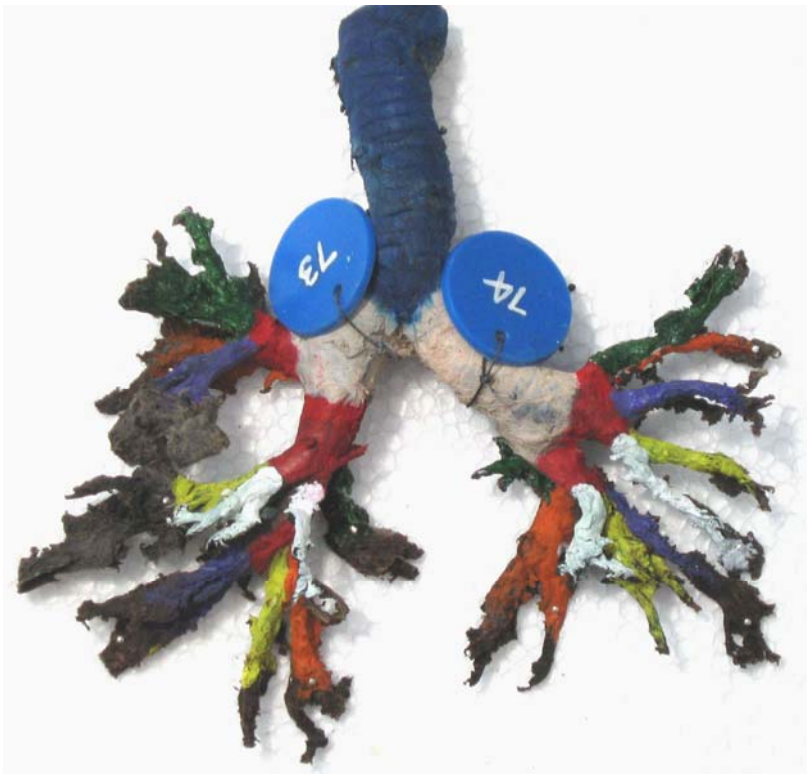
RIGHT LOWER LOBE SUPERIOR SEGMENT - BIFURCATION





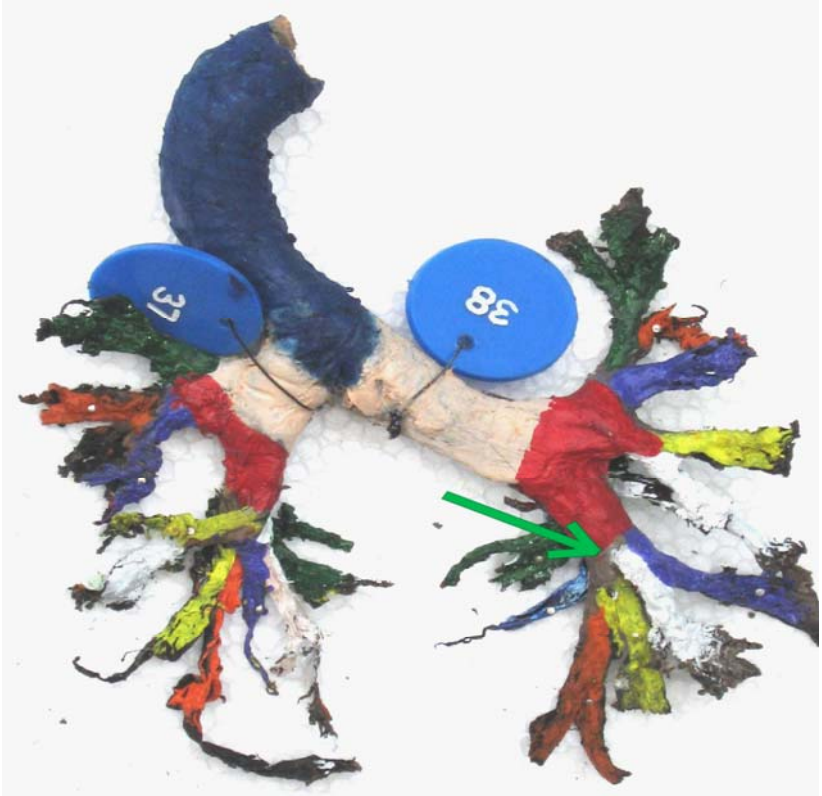
RIGHT LOWER LOBE SUB SUPERIOR PRESENT

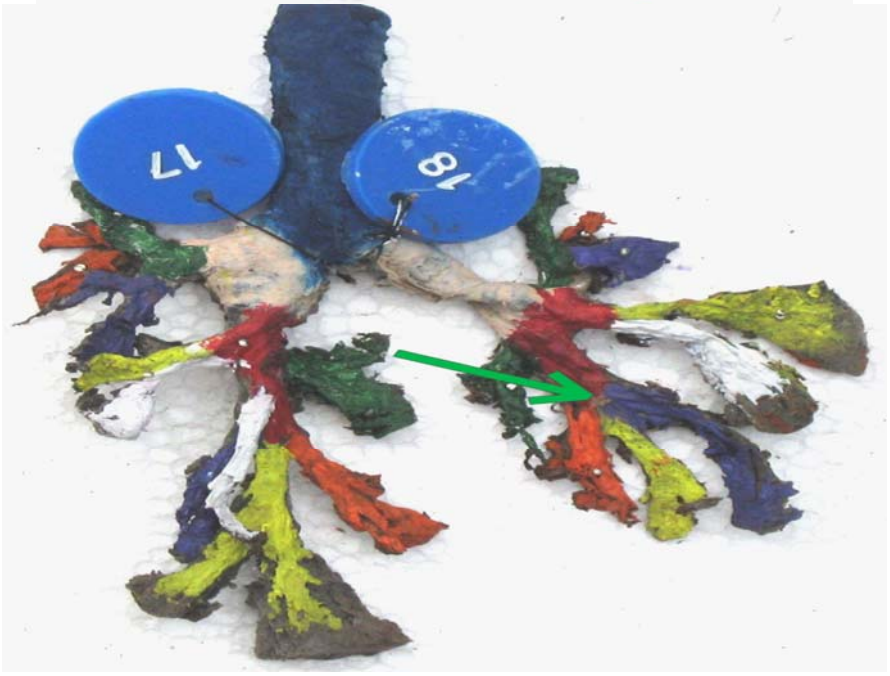
LEFT UPPER LOBE - BIFURCATION



LEFT UPPER LOBE - TRIFURCATION

LEFT LOWER LOBE BASAL TRUNK – BIFURCATION (ANTEROMEDIAL SEGMENT)





LEFT LOWER LOBE BASAL TRUNK – TRIFURCATION (MEDIAL BASAL ABSENT)

SUPERIOR SEGMENT TRIFURCATION

SUB SUPERIOR BOTH LUNGS

MASTER CHART																																								
Serial No.	Trachea			Primary Bronchus									Right Lung																Left Lung											
				Right					Left				RUL			RML				RLL								LUL				LLL							
																					Superior segment					Basal Trunk												
																					Orifice			Branching pattern															
	Diameter (cm)	Length (cm)	Number of rings	Length (cm)	Angle	divisions			Length (cm)	Angle	divisions		Position (ep)	Bifur	Trifur	Position (hyp)	Length (mm)	bifur	Trifur	Position (hyp)	Same or Overlap	Separate	Sub superior	Bifur	Trifur	Bifur	Trifur	Position (hyp)	Bifur	Trifur	Position (hyp)	Position (hyp)	Superior segment			Basal trunk		
						Upper BEH	Middle OEH	Lower OEH			Upper (wh)	Lower (wh)																											
1	1.8	7	18	2.5	25	√	√	√	4.3	75	√	√	√	√		√	12	√		√	√		√	√		√		√	√		√	√		√		√			√
2																																								
3	1.8	6.7	17	2.8	35	√	√	√	4	80	√	√	√	√		√	20	√		√		√	√	√		√		√		√	√		√	√		√	√		
4																																								
5	2.5	10	14	2.1	50	√	√	√	4.3	75	√	√	√		√	√	13	√		√		√	√	√		√		√	√		√	√		√		√			√
6																																								
7	1.3	7	16	2	40	√	√	√	4.2	80	√	√	√	√		√	12	√		√		√	√	√			√	√	√		√	√		√	√				
8																																								
9	1.8	11	18	1.3	45	√	√	√	4.6	70	√	√	√	√		√	20	√		√	√		√	√		√		√	√		√	√		√	√		√		
10																																								
11	1.8	10	16	1.8	35	√	√	√	4.3	73	√	√	√	√		√	6		√	√		√	√	√		√		√	√		√	√		√	√		√		
12																																								
13	1.9	12	18	1.2	25	√	√	√	4.3	80	√	√	√		√	√	14	√		√		√	√	√		√		√		√	√		√	√		√		√	√
14																																								
15	2	10	19	2.5	45	√	√	√	4.5	75	√	√	√	√		√	15	√		√	√		√		√	√		√	√		√	√		√	√		√		√
16																																								
17	1.8	11	15	2.3	35	√	√	√	4.8	73	√	√	√		√	√	18	√		√		√		√		√		√	√		√	√		√	√		√	√	
18																																								
19	1.8	12	20	1.7	35	√	√	√	4.7	80	√	√	√	√		√	5	√		√		√	√	√		√		√		√	√		√	√		√	√		
20																																								
21	2.4	11	17	1.4	45	√	√	√	4.3	70	√	√	√		√	√	24	√		√		√	√	√		√		√		√	√		√	√		√	√		
22																																								
23	2.5	13	19	2.4	40	√	√	√	4.8	74	√	√	√	√		√	8	√		√		√	√	√		√		√	√		√	√		√		√			√
24																																								
25	1.4	6.5	17	2	35	√	√	√	3.5	75	√	√	√	√		√	10	√		√	√		√	√		√		√	√		√	√		√	√		√	√	
26																																								
27	1.8	8	20	2.5	30	√	√	√	4	75	√	√	√	√		√	20	√		√	√		√		√	√		√	√		√	√		√	√		√	√	
28																																								

Serial No.	Trachea			Primary Bronchus									Right Lung																Left Lung											
				Right					Left				RUL			RML				RLL								LUL			LLL									
																					Superior segment																		
						divisions					divisions										Orifice			Branching pattern		Basal Trunk														
	Diameter (cm)	Length (cm)	Number of rings	Length (cm)	Angle	Upper BEH	Middle OEH	Lower OEH	Length (cm)	Angle	Upper (wh)	Lower (wh)	Position (ep)	Bifur	Trifur	Position (hyp)	Length (mm)	bifur	Trifur	Position (hyp)	Same or Overlap	Separate	Sub superior	Bifur	Trifur	Bifur	Trifur	Position (hyp)	Bifur	Trifur	Position (hyp)	Superior segment			Basal trunk		
																															Bifur	Trifur	Sub superior	Bifur	Tri
29	1.8	7.5	15	2.3	40	√	√	√	4	70	√	√	√	√		√	14	√		√		√	√	√		√		√	√		√	√		√	√	
30																																				
31	2.4	11	15	2.5	30	√	√	√	4.2	75	√	√	√		√	√	18	√		√		√	√	√		√		√	√		√	√		√	√	
32																																				
33	2.3	8.5	20	2	40	√	√	√	4	80	√	√	√	√		√	15	√		√		√	√	√		√		√	√		√	√		√	√	
34																																				
35	1.8	7	19	2.5	40	√	√	√	4.3	75	√	√	√		√	√	13	√		√	√		√	√			√	√	√		√	√		√	√	
36																																				
37	2.2	10	19	3	35	√	√	√	5	71	√	√	√	√		√	12	√		√		√		√		√		√	√		√	√		√	√	
38																																				
39	2.5	9	15	2.7	40	√	√	√	4.5	65	√	√	√	√		√	15	√		√	√		√		√	√		√	√		√	√		√	√	
40																																				
41	2.3	12	16	1.2	35	√	√	√	4.4	75	√	√	√	√		√	6	√		√		√	√	√			√	√	√		√		√	√	√	
42																																				
43	2.4	11	14	2	20	√	√	√	4.1	75	√	√	√	√		√	13		√	√		√	√	√		√		√	√		√	√		√	√	
44																																				
45	1.8	8	17	2.7	35	√	√	√	4	65	√	√	√		√	√	15	√		√		√	√	√		√		√	√		√	√		√	√	
46																																				
47	2	10	20	2	40	√	√	√	4.2	75	√	√	√	√		√	12	√		√		√	√	√		√		√	√		√	√			√	√
48																																				
49	2.5	11	20	1.9	40	√	√	√	4.3	70	√	√	√	√		√	23		√	√	√		√	√			√	√	√		√	√		√	√	
50																																				
51	2.4	12	21	1.3	35	√	√	√	3.5	80	√	√	√	√		√	12	√		√		√	√	√		√		√	√		√		√	√	√	
52																																				
53	2.5	11	16	1.8	40	√	√	√	4.2	75	√	√	√	√		√	17	√		√		√	√	√		√		√	√		√	√			√	√
54																																				
55	2.5	11	19	2.1	45	√	√	√	4.6	70	√	√	√	√		√	8	√		√		√	√	√		√		√	√		√	√		√	√	
56																																				
57	2	7	14	2.7	40	√	√	√	4.5	75	√	√	√		√	√	18	√		√		√	√	√		√		√	√		√	√		√	√	

Serial No.	Trachea			Primary Bronchus								Right Lung															Left Lung									
				Right					Left			RUL			RML				RLL									LUL			LLL					
																				Superior segment															
																				Orifice		Sub superior	Branching pattern		Basal Trunk										
	Diameter (cm)	Length (cm)	Number of rings	Length (cm)	Angle	divisions			Length (cm)	Angle	divisions																								
						Upper BEH	Middle OEH	Lower OEH			Upper (wh)	Lower (wh)	Position (ep)	Bifur	Trifur	Position (hyp)	Length (mm)	bifur	Trifur	Position (hyp)	Same or Overlap	Separate		Bifur	Trifur	Bifur	Trifur	Position (hyp)	Bifur	Trifur	Position (hyp)	Bifur	Trifur	Bifur	Tri		
58	2	7	14	2.7	40	√	√	√	4.3	75	√	√	√		√	√	18	√		√		√	√	√		√			√	√		√	√	√	
59	2.4	12	17	2.2	30	√	√	√	4.3	70	√	√	√	√		√	25	√		√		√	√	√		√			√	√		√	√		
60																																			
61	1.9	11	15	1.2	50	√	√	√	4.8	80	√	√	√	√		√	20	√		√		√	√	√		√			√	√		√	√		
62																																			
63	2	13	16	1.3	25	√	√	√	4.9	65	√	√	√		√	√	14	√		√	√		√	√		√			√	√		√	√		
64																																			
65	2.1	15	15	1.9	40	√	√	√	4.2	75	√	√	√	√		√	9	√		√		√	√	√		√			√	√		√	√		
66																																			
67	1.9	12	18	2.3	35	√	√	√	4.6	70	√	√	√		√	√	28	√		√		√	√	√		√			√	√		√	√		
68																																			
69	2.3	14	16	1.4	45	√	√	√	4.8	75	√	√	√	√		√	19	√		√		√	√	√		√			√	√		√	√		
70																																			
71	2.5	13	20	2.4	40	√	√	√	4.6	75	√	√	√	√		√	13	√		√	√		√		√	√			√	√		√	√		
72																																			
73	1.9	15	18	1.6	25	√	√	√	4.4	75	√	√	√		√	√	8	√		√		√	√		√	√			√	√		√	√		
74																																			
75	2.4	11	19	1	50	√	√	√	4.8	75	√	√	√	√		√	25	√		√		√	√	√		√			√	√		√	√		√
76																																			
77	1.9	14	18	2	35	√	√	√	4.3	65	√	√	√		√	√	18	√		√		√	√	√		√			√	√		√	√		
78																																			
79	1.8	13	17	2.5	35	√	√	√	4.8	75	√	√	√		√	√	12	√		√	√		√	√		√			√	√		√	√		√
80																																			
81	2.1	15	20	1.3	25	√	√	√	4.5	70	√	√	√		√	√	22	√		√		√	√	√		√			√	√		√	√		
82																																			
83	2	12	18	2.1	45	√	√	√	4.2	80	√	√	√	√		√	7	√		√		√	√	√		√			√	√		√	√		√
84																																			
85	2.4	13	22	1.9	35	√	√	√	4.8	75	√	√	√		√	√	13	√		√	√		√	√		√			√	√		√	√		

Serial No.	Trachea			Primary Bronchus									Right Lung																Left Lung									
				Right					Left				RUL			RML				RLL								LUL			LLL							
																					Superior segment																
																					Orifice		Sub superior	Branching pattern		Basal Trunk											
	Diameter (cm)	Length (cm)	Number of rings	Length (cm)	Angle	divisions			Length (cm)	Angle	divisions		Position (ep)	Bifur	Trifur	Position (hyp)	Length (mm)	bifur	Trifur	Position (hyp)	Same or Overlap	Separate		Bifur	Trifur	Bifur	Trifur	Position (hyp)	Bifur	Trifur	Position (hyp)	Superior segment			Basal trunk		
						Upper BEH	Middle OEH	Lower OEH			Upper (wh)	Lower (wh)																				Bifur	Trifur	Sub superior	Bifur	Tri
86	2.4	13	22	1.9	30	√	√	√	4.6	75	√	√	√		√	√	13	√		√	√		√	√		√		√	√		√						
87	2.1	11	19	2.2	40	√	√	√	4.3	75	√	√	√	√		√	21	√		√		√	√		√	√	√		√	√		√	√		√	√	
88																																					
89	2.5	15	20	2.3	30	√	√	√	4.3	70	√	√	√	√		√	17	√		√		√	√	√		√		√	√		√	√		√		√	√
90																																					
91	2.3	16	18	1.4	50	√	√	√	4.4	65	√	√	√	√		√	22	√		√	√		√	√		√		√	√		√	√		√	√	
92																																					
93	2	13	19	1.8	40	√	√	√	4.2	75	√	√	√	√		√	5	√		√		√		√		√		√	√		√		√	√	√	
94																																					
95	2.6	14	20	1.2	30	√	√	√	4.1	80	√	√	√	√		√	11	√		√	√		√	√		√		√	√		√	√		√	√	
96																																					
97	1.9	13	19	1.6	35	√	√	√	3.8	73	√	√	√	√		√	6	√		√	√		√	√		√		√	√		√	√		√	√	
98																																					
99	1.9	14	18	2.4	30	√	√	√	4.3	70	√	√	√		√	√	16	√		√		√	√	√		√		√	√		√	√		√	√	
100																																					